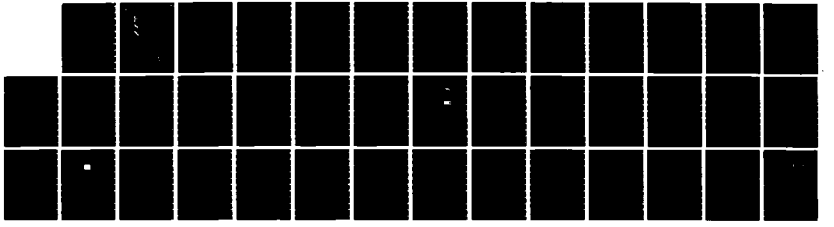
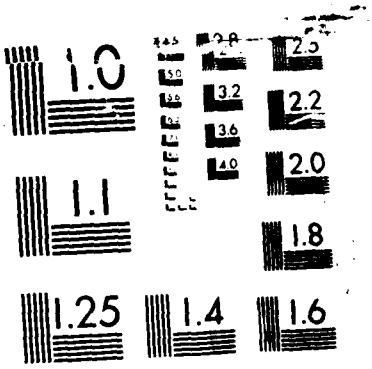
AD-A168 089 EUROPEAN SCIENCE NOTES VOLUME 40 NUMBER 7(U) OFFICE OF 1/1
NAVAL RESEARCH LONDON (ENGLAND) C J FOX JUL 86

UNCLASSIFIED F/G 5/2 NL





U.S. Office of Naval Research, London
Vol 40 No. 6/7 July 1986

European Science Notes

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

AD-A168089

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 40-7	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION US Office of Naval Research Branch Office, London 6b OFFICE SYMBOL (If applicable) ONRL	7a NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Box 39 FPO, NY 09510	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) European Science Notes--(UNCLASSIFIED)	
12. PERSONAL AUTHOR(S) C.J. Fox, Editor	
13a. TYPE OF REPORT Monthly 13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) July 1986 15 PAGE COUNT 33
16. SUPPLEMENTARY NOTATION	
17. COSATI CODES FIELD / GROUP / SUB-GROUP	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL C.J. Fox	22b TELEPHONE (Include Area Code) (44-1) 409-4340 22c OFFICE SYMBOL 11

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

U.S. Government Printing Office: 1985—607-047

European Science Notes

US Office of Naval Research, London

Commanding Officer ..... CAPT M.A. Howard, USN
Scientific Director ..... David L. Venezky
Editor ..... C.J. Fox

July 1986
Volume 40
Number 7

Biological Sciences

Computer Sciences

Mechanics

Important projects in the Fluid Mechanics and Heat Transfer Laboratory are wind tunnel and water channel experiments directed toward improved understanding of coherent near-wall turbulence structures. The quality of this work suggests significant contributions in the future provided the current level of funding continues.

Research being conducted at the Institut de Mechanique des Fluides de Lille (IMFL) by the aerodynamics group is concerned with unsteady and separated flows, aerodynamics of explosions and gunfire, turbulent flows, and flow characterization techniques. IMFL's experimental work is highlighted in this article since their computational activities, particularly those undertaken by Vandromme, are already very well known in the United States.

Ocean Sciences

The University College of North Wales appears to be in the process of developing a first-class oceanographic research activity. By contrast, Exeter University, has no oceanographic department, but some noteworthy work is being done there by individual scientists.

Physics

A brief overall review and evaluation of the 50th Annual Meeting of the German Physical Society (Heidelberg, 17 through 21 March 1986) is presented. The program of the quantum optics division is covered in more detail.

News and Notes

* * *

ESN Invites Letters to the Editor

ESN publishes selected letters related to developments and policy in science and technology in Europe and the Middle East or to interactions between the US and Europe and the Middle East in science and technology.

Letters intended for publication should be limited to 250 words and should include the writer's name, address, and daytime telephone number. Send your contributions to:

The Editor
ESN
Office of Naval Research Branch Office
Box 39
FPO, NY 09510-0700

Not all letters can be used; letters may be edited for reasons of space and clarity.

* * *

Subscriptions: ESN is distributed free to members and close associates of the US Government's R&D community. Others may take advantage of our subscription service: 12 issues, domestic subscriber, $27; 12 issues, foreign subscriber, $33.75; single issue, domestic, $2.25; single issue, foreign, $2.81. For a paid subscription, write to: Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

European Science Notes is a Class I Periodical prepared and distributed by the Office of Naval Research, London, in accordance with NAVSO P-35.

Biological Sciences

LIFE SCIENCES RESEARCH AT THE INSTITUTE FOR BIOCHEMISTRY, FREE UNIVERSITY OF BERLIN

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1987 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

The Free University of Berlin is, along with the universities of Tübingen and Hannover, one of the three German universities at which students can obtain a degree in biochemistry at undergraduate and graduate levels. (Other universities--for example, University of Göttingen--have departments of biochemistry but do not award degrees in biochemistry.) The Institute for Biochemistry, whose present director is V.A. Erdmann, is of recent origin, having been established only in 1976.

Thesis research in biochemistry is not limited to the institute--it can also be carried out at other institutes such as the Max Planck Institute for Molecular Genetics, the Fritz Haber Institute, the Robert Koch Institute, and the Institute of Basic Medicine and Biology. Because of the limited possibility of studying biochemistry in Germany, the graduates of the Institute for Biochemistry have very good prospects for obtaining employment in their field. Research projects at the Institute of Biochemistry are funded not only by the Free University of Berlin, but also by the German Research Community, the Federal Ministry for Research, and grants from industry.

The research projects at the institute include: gene expression, with emphasis on protein synthesis; nucleic acids structure and function; protein/nucleic-acid interactions; molecular evolution; gene technology; and, recently, the molecular biology of archaebacteria. Research in these areas is under the direction of V. Erdmann. F. Hucho's group is engaged in studies of the biochemical characterization of acetylcholine receptors. E. Riedel and his research group are studying the biochemical mechanisms of drugs and natural substances, especially of centrally effective compounds; metabolism of transmitter substances; membrane functions; and transport events in biological membranes.

Following is a summary look at some of the research being conducted under Erdmann (small molecular weight RNAs), Hucho (neurochemistry), and Reidel (biological mechanisms of drugs and natural substances).

Small Molecular Weight RNAs

V. Erdmann and coworkers are carrying out detailed studies on the structure and evolution of the 5S ribosomal RNA (5S rRNA). In the molecular organization of cellular activity, protein biosynthesis occupies a position of central significance. The genetic information encoded in DNA and transcribed to messenger RNA (mRNA) is expressed as proteins. Ribosomes are the organelles responsible for protein synthesis in living cells. Even in the best studied system, that of the bacterium *E. coli*, only the general structures and functions of the ribosome are understood; i.e., the details of protein-protein, protein-nucleic acid, and nucleic acid-nucleic acid interactions and their regulation is still to be resolved. A promising approach to these complex problems is to analyze in detail parts of the ribosome for their structure and function. Erdmann et al. have selected the ribosomal 5S and 5.8S RNAs and their protein complexes for such a detailed structural and functional study.

5S rRNA is an integral part of the large ribosomal subunits of pro-and eukaryotic ribosomes while the eukaryotic 60S ribosomal subunit contains a second small ribosomal RNA designated as 5.8S RNA. Comparative structural analysis by Erdmann et al., as well as by other research groups, has led to a general secondary structure for 5S rRNA which is in agreement with a large number of physical, chemical, and biochemical studies. However, its tertiary structure, as well as its functional properties, remains to be worked out. Erdmann et al. are using base specific, partial chemical modification to gain information about the tertiary structure of the 5S rRNA molecule--the folding of the entire molecule of 5S rRNA in the third dimension defines the tertiary structure of this molecule. To gain information on the 5S RNA tertiary structure, they are using biophysical methods, such as neutron-bending analyses, infrared spectroscopy, and proton exchange measurements. In addition, they

are using high-resolution electron microscopy for the examination of the free 5S rRNA and of 50 ribosomal subunits which contain this small RNA.

In resolving the function of 5S rRNA, Erdmann and colleagues had to ascertain the components with which it interacts. By affinity chromatography, these ribosomal proteins from *E. coli* could be bound to immobilized 5S rRNA; i.e., E-L5, E-L18, and E-L25 as well as homologous proteins from other organisms. 5S rRNA fragments were generated for the determination of the binding area of these proteins on the 5S rRNA and examined as to their capability for forming complexes. Erdmann et al. carried out studies on the reconstitution of 5S rRNA subunits from the individual components; this permitted the exchange of the authentic 5S rRNA (with its fragments) with specifically changed 5S rRNA species, thus permitting subsequent analysis of the biological activity in an *in vitro* protein biosynthetizing system. Using this approach, as well as a function test which determines the fault ratio of the peptide built in, the functionally important areas of 5S rRNA can be analyzed.

Erdmann et al. found that a special complex of 5S rRNA and a single protein was formed during the course of oogenesis by *Xenopus laevis*. This protein, however, was not a ribosomal protein but a molecule which recognizes 5S rRNA as a transcription co-factor. In order to study the binding of this eukaryotic transcriptor factor (termed TFIIIA) to heterologous 5S rRNAs with a low degree of overall sequence conservation (less than 20 percent), Erdmann et al. utilized a transcription competition assay involving eubacterial, archaebacterial, and eukaryotic 5S rRNAs. All the molecules were found to inhibit *Xenopus* 5S rRNA transcription, specifically suggesting that only a small amount of specific, conserved RNA sequences--indeed, if any--are essential for the interaction of the transcription factor with the 5S rRNA molecules, whereas universal 5S rRNA secondary structural elements seemed to be required. A fragment of *Xenopus laevis* oocyte 5S rRNA (nucleotides 41-120) which partially maintains the original 5S rRNA structure also competes for the TFIIIA. *In vitro* transcription of a naturally occurring mutant of the *Xenopus laevis* oocyte 5S rRNA gene, the pseudogene, which carries several point mutations within the TFIIIA binding domain, is equally inhibited by exogenous *Xenopus* 5S rRNA.

Erdmann et al., in order to obtain a more detailed insight into the sequence requirements for the promotion of 5S gene transcription, have introduced C-to-T transitions into GC and CG base pairs of the *Xenopus laevis* somatic 5S gene coding region and its 5' flank. These studies allowed the researchers to differentiate between the two promoter elements and their spacer within the internal control region. Mutations within the 5' element which dissent from the corresponding tRNA consensus sequence reduced transcription activity substantially without significantly affecting TFIIIA binding. Mutations in the spacer region had no pronounced effect on transcription. The 3' promoter element was found to extend to position 97, since mutations in this region interfered with transcription activity. This could be attributable, at least partially, to a reduced competition strength for TFIIIA.

Since 5S rRNA has been found in all organisms examined, it is particularly suitable for molecular evolution studies. The analysis of the mutations in more than 100 sequenced 5S rRNA molecules by computer analysis, has enabled Erdmann et al. to construct a "family tree." They found that there are two structural and functional groups of 5S rRNA--eukaryotic and prokaryotic. Archaebacteria assume an intermediate position while chloroplast 5S rRNA was found to be of eubacterial nature and closely related to cyanobacteria.

Erdmann et al. recently determined the nucleotide sequence of 5S rRNA from an extreme thermophile, *Thermus thermophilus* HB8. It was previously found that 5S rRNAs from extreme *thermophilus* have more rigid structure than those from mesophilic organisms so these 5S RNAs are more suitable for some physicochemical studies of 5S rRNA. Erdmann et al. found that the 5S rRNA of *T. thermophilus* HB8 contains at least two terminal heterogeneities, one at the 5'-end and the other at the 3'-end.

Neurochemistry

F. Hucho and his group are engaged in studies of the biochemical characterization of acetylcholine receptors. These researchers are using the electric tissue of *Torpedo marmorata* which contains a very large number of nicotinic cholinergic synapses. They are using this as a model system to study molecular events in the nervous system in order to explain the principal function of the neurons; namely, the transmission of signals. The cholinergic synapses of the electric organs are similar in many respects to the neuromuscular end-plate of mammals at which the signal transmission from the nerve cell to the muscle cell takes place and thus can be considered a good model system for higher

organisms. Furthermore, it is possible to obtain almost pure preparations of postsynaptic membranes in the form of protein-lipid vesicles from the electric organ of *T. marmorata*. More than 50 percent of the proteins consist of acetylcholine receptors.

The nicotinic acetylcholine receptor (ACLR) has two functions: signal recognition (ligand binding) and ion channel gating. The latter function is thought to be related to conformational changes within the receptor protein. Such changes have been observed through a variety of methods. One of the principal unsolved questions concerning the functional mechanism of the receptor is the following: What is the difference between agonists which bind to the ACHR and cause opening of the ion channel, and antagonists which bind competitively but have no effect on the gating mechanism?

Hucho et al. are tackling this question in their studies of ACLR by investigating the gating mechanism itself by means of noncompetitive receptor ligands which have been shown to interact with and to block the ion channel directly. The interaction of some of these noncompetitive blockers with the ACLR ion channel can be a sensitive indicator for monitoring structural changes within the channel or its gating device. Hucho et al. have used the channel ligand $TPMP^+$ (triphenylmethylphosphonium) and a rapid photolabeling technique for the covalent labeling of ACLR polypeptide chains at different time lapses after mixing the membrane-bound receptor with cholinergic effectors.

Hucho et al. were especially interested in the kinetics of the antagonist-stimulated photolabeling which they had observed previously. The allosteric model of the ACLR does not include antagonist-induced conformational states; only agonists are considered as capable of activating (opening) and inactivating (desensitizing) the receptor and its ion channel. Hucho et al. found that in the resting and activated state, most of the photoaffinity label is incorporated into the α-polypeptide chains of the receptor complex. When equilibrated with agonists and antagonists, the δ-polypeptide chain (and to a lesser extent the β-chain) reacts with the photolabel. Reactivity of the δ-chain increases after exposure to cholinergic effectors with a half-life slower than the kinetics of receptor activation or rapid desensitization. Agonists and antagonists stimulate photolabeling of the δ-chain with different kinetics. For acetylcholine, carbamoylcholine and suberyldicholine the half-life of the reactivity increase is 400 to 500 milliseconds; for the antagonists hexamethonium, d-tubocurare, and flaxedil it is about 10 seconds. The latter slow kinetics are also observed when the receptor is preequilibrated with agonists or antagonists prior to mixing with $[^3H]TPMP^+$ and starting the photoreaction. Thus, Hucho et al. were able to show that time-resolved photoaffinity labeling can conveniently mark protein structures involved in receptor functions. Of special interest is the observation that antagonists also induce a comformational change in the receptor protein. It should be noted that only the laser-flash method of photoaffinity labeling of ACLR with $[^3H]TPMP^+$ as used by Hucho et al. provides a time resolution comparable to physiological events.

Biological Mechanisms of Drugs and Natural Substances

E. Riedel and his group have been working for the past few years on the development of quantitative analytical methods for drugs used for treatment of diseases of the central nervous system (CNS) or endogenous substances in blood or tissues, and their interactions with serum proteins, enzymes, or cell membranes. Their main interest is in centrally effective substances from plants. Especially in diseases of the CNS, only empirical methods of treatment are being used for the most part (e.g., in epilepsy). A targeted cause and protective therapy can be employed only in a very few cases whose molecular biological basis has been identified (e.g., in phenylketonuria, a genetically caused defect of phenylalanine hydroxylase). As their biochemical effect is clarified, empirically found or developed drugs can possibly be used to define causes of diseases of the CNS.

Riedel and his group have carried out quantitative analysis and protein binding of drugs in serum and tissue, including centrally effective drugs in the phenathazine group (neuroleptics), alkaloids (circulatory regulation), antiepileptic drugs, and others (propanolol, strophanthin). Riedel et al. developed new and improved quantitative analyses such as gas chromatography for the neuroleptic Perazin and the β-receptor blocker, propanolol, and thin-layer chromotography for the ergot alkaloids, dihydroergotamine and dihydroergokryptin. The determination of the unusually high binding affinity for serum proteins of the phenothiazene derivative, Perazin ($K=3.8\times10^5$ mol/l) on acid α_1-glycoprotein led to a series of model examinations of protein-ligand interactions.

Riedel et al. are also studying interactions of drugs with biological

membranes. Antiepileptic drugs (e.g., diphenylhydantoin) do not, in general, have high affinity reactions with proteins or cell components. The total effect of antiepileptic drugs is a result of complex interlinked partial effects. Classical receptor binding studies, therefore, are of no use in the classification of the effect of antiepileptic drugs. The most significant aspect of these drugs is their high lipid; i.e., membrane solubility. Therefore, Riedel et al. have developed methods for obtaining homogenous synaptic membrane fractions from various animal species such as cattle, rat, and Göttinger minipig, and are looking for methods to isolate the membrane functions with highest binding affinity for diphenylhydantoin. They are also engaged in collaborative studies of the preparative separation of membrane-integrated proteins by sodium dodecylsulfate (SDS) using high-pressure liquid chromatography; this is being done with researchers at the Max Planck Institute for Molecular Genetics in Dahlem (Berlin).

In addition, Riedel et al. are also examining the influences of certain enzymes which play a significant role in the functions of the central nervous system. Specifically, they have been studying acetylcholinesterase--which is involved in the down regulation of the most important neurotransmitter of the nervous system, acetylcholine--and the effects of 2-oxyglutaraminotransferase with semisuccinaldlhydroxydoreductase, which are involved in the downgrading of the neurotransmitter γ-aminobutyric acid (GABA) with actions opposite to that of cholinesterase. With respect to the effects of acetylcholinesterase on the postsynaptic membrane of the neuron and nonspecific cholinesterase present in surrounding glial cells, Riedel et al. have been using various drugs to examine the kinetics of inhibitions of both esterases. They used phenothiazines such as Perazine and Chlorpromazine, as well as ergot alkaloids, especially ergotamine, dihydroergotamine. In preliminary studies, Riedel et al. have found that Perazin and ergotamine exhibited pharmacologically relevant inhibitor contents in the molar range.

Riedel et al. are also investigating compounds from Valerian root extracts for anticonvulsive effects. Before the development of synthetic anticonvulsive-effective drugs such as barbiturates, succinimides, and diphenylhydantoin (which often have unpleasant side effects), one of the most important but conditionally effective therapies was the use of Valerian root extracts. Riedel et al. are presently examining specific components of Valerian root extracts (such as the valeranates, valeronolic acid, and acetoxyvalerenolic acid) which are significant inhibitors of the GABA-degrading enzyme, GABase for their anticonvulsive effects. These studies are being carried out with the hope of finding antiepileptic compounds with less side effects than the synthetic compounds presently in use.

DNA Synthesis

V. Erdmann and his coworkers are presently engaged in studies of DNA snythesis. The increased utilization of gene technology methods in basic research and in biotechnology makes it possible to synthesize DNA in a goal-oriented manner. In principle, there are seven areas in which such synthesized DNA can be used. These are:

1. Linker and primer. Necessary for the connection of larger DNA fragments with one another or to start an enzymatic DNA synthesis.
2. Gene synthesis. The artificial synthesis of genes can be accomplished by the coupling of various DNA fragments in a targeted way. By use of specific methods, these genes can be inserted into bacterial cells and manipulated to express gene products.
3. Mutagenesis. The possibility of synthesizing genes allows one to change these genes at certain locations so that the gene product (protein or RNA) has a different structure and thereby might exhibit a different function.
4. DNA structure. In order to investigate the regulatory elements of DNA, it is necessary to produce oligonucleids in larger amounts in order to characterize them chemically and enzymatically by means of physical methods such as Nuclear Magnetic Resonance (NMR) spectroscopy and x-ray structure analysis. DNA synthesis by gene technology promotes the amounts of DNA required for such analyses.
5. Genetic diagnosis. The utilization of synthetic DNA fragments makes possible the localization of possible genetic defects of living organisms.
6. Evolution. The question of the origin of organisms can be examined by sequence comparison of DNA and RNA. If these molecules are present only in small amounts, gene technology methods can be used to enrich them in sufficient amounts for examinations.
7. RNA synthesis. Since chemical RNA synthesis is significantly more difficult than DNA synthesis, methods are being worked out to transcribe DNA enzymatically to complementary RNA molecules.

In Erdmann's laboratories, all the above areas are being pursued actively and the DNA synthesized is being used by this group as well as in collaborative studies with other groups at the Max Planck Institute for Molecular Genetics and the Medical Biology Divisions of the Free University of Berlin.

Conclusion

Scientists at the Institute of Biochemistry, Free University of Berlin, have been very productive and are making important contributions even though the institute was founded only 20 years ago. The research emphasis is in molecular biology, gene technology, neurochemistry, and biochemical mechanisms of drug action.

4/11/86

RESEARCH AT THE INSTITUTE FOR BIOCHEMISTRY AND MOLECULAR BIOLOGY, TECHNICAL UNIVERSITY OF BERLIN

by Claire E. Zomzely-Neurath.

Introduction

The origin of today's Technical University of Berlin was the Bergakadamie founded by Frederick the Great in 1770; it later became the Charlottenburg Hochschule, a focus of technological progress in the early 19th century. However, the organization and academic structure establishing a true technical university covering a wide range of scientific disciplines including engineering and architecture as well as biotechnology was carried out only about 20 years ago. At present, about 2000 research projects are being carried out in both basic and applied research areas with emphasis on the latter. Many research projects involve collaboration with various departments at the Free University of Berlin as well as with industry.

The Institute for Biochemistry and Molecular Biology of the Technical University of Berlin is one of the newest institutes of the university, having been organized in the late 1970's. Under the direction of H. Kleinkauf, this institute has evolved into a major division of the university. The major areas of research emphasis are: (1) vectorial processes on biological membranes; (2) structure, function, and biosynthesis of peptides with particular emphasis on the biosynthesis of antibiotic peptides on multifunctional protein templates and the enzymate synthesis of bioactivepeptides; and (3) degradation and biological inactivation of neuropeptides.

Following are discussions of research projects of particular interest. These concern:

- Degradation and biological inactivation of neuropeptides
- Degradation of TRH
- Degradation of luteinizing hormone-releasing hormone (LH-RA)
- Degradation of enkaphalin
- Degradation of substance P
- Carnosine and related peptides
- Biosynthesis of antibiotic peptides.

Degradation and Biological Inactivation of Neuropeptides

An ever-increasing number of neuropeptides have been identified in recent years. These substances act as neurohormones, neuromodulators, neurotransmitters, or paracrine effector substances on a variety of target cells via binding to specific receptors. As for other signal-transmitting substances, it is mandatory that highly efficient elimination systems also exist for neuropeptides. Otherwise, the concentration of these substances would build up so that further secretion would lead only to a neuronal increase in their concentration, making their function as messengers impossible. This is especially true for neuronal communication factors. For substances which are released with high frequency, these mechanisms not only have to be very efficient but they also have to be very rapid.

K. Bauer and coworkers have been carrying out extensive studies on the degradation and biological inactivation of neuropeptides.

In vitro, rapid degradation by blood and tissue enzymes has been observed for all neuropeptides, but the physiological functions of these enzymes within the mechanisms of neuropeptide metabolism have thus far remained obscure. For the neuropeptide-synthesizing cells, some as yet unknown mechanisms must exist to regulate intracellular concentrations. After release of neuropeptides and their interaction with the receptors, some mechanisms must exist to clear the target cell for the transmission of the next signal. As shown for some neuropeptides and several proteohormones, peptides may enter the target cell by receptor-mediated endocytosis. The fate of the peptide-receptor complex is unknown in most cases, but it appears that the peptides are degraded by lysosomal or cytosolic enzymes.

Internalization of peptides is a relatively slow process but seems to be adequate for peptides which are released with very low frequency or where the peptides exhibit an extremely low dissociation content. For other peptides, these processes are too slow. After termination of action, which occurs exclusively at the receptor level through the dissociation of the peptide-receptor complex, the peptide could be removed from the site of target interaction by diffusion. In the central nervous system (CNS) the dissociated peptide could diffuse out of the synaptic cleft but would have to be degraded thereafter by enzymes associated with other cells (e.g., glial cells, endothelial cells, etc.) or localized on neurons remote from the receptor sites. Obviously, such enzymes which serve general scavenger functions are biologically most important: they maintain the system of directed communication by preventing the peptides from diffusion to other target sites and their accumulation in the cerebral spinal fluid (CSF).

For peptides which are released with high frequency, the synaptic cleft must be cleared. Diffusion processes alone may be too slow and it would be expected that the removal of peptidergic transmitters from the synaptic cleft is facilitated by additional mechanisms, as is known for the classical neurotransmitters. Catecholamines, for example, are known to be rapidly removed from the synaptic cleft by re-uptake into the secreting cell where they are metabolized by intracellular enzymes. For neuropeptides, however, inactivation through an energy-dependent uptake process has not been convincingly demonstrated. Thus, it seems more likely that peptidergic neurotransmitters are degraded by peptidases localized in the vicinity of the receptors. Such enzymes cannot act as a "switch" for turning off peptidergic signals, but can only fulfill a specialized scavenger function. For this target site clearance function these enzymes would be expected to exhibit a high turnover number and to be present in sufficiently high concentration. Such enzymes, however, do not necessarily have to have a high affinity and specificity for a given peptide. Primarily determined by their specific localization, even peptidases with limited substrate specificity could directly influence the transmission of the peptidergic signal. The degradation of each peptide appears to be catalyzed by not only one enzyme, as in the case of acetylcholine, but by several enzymes, and the different fragments formed are subject to further degradation by other enzymes. The degradation of these substances to the free amino acids as final degradation products gives rise to a very complex fragmentation pattern. In addition, there are no biochemical criteria to distinguish peptidases serving target site cleaner functions from enzymes serving other functions.

Bauer et al. have been carrying out studies to find an understanding of the biological functions of neuropeptide-degrading enzymes on the basis that it is necessary first to delineate the pathways of neuropeptide fragmentation and to elucidate the biochemical properties of the individual enzymes capable of hydrolyzing these substances. Information from such studies should then provide the tools to answer more specific questions as to the function of the individual enzymes at specific sites.

Degradation of TRH

In studies of the degradation of thyrotropin-releasing hormone (TRH), Bauer et al. found that this tripeptidamide was degraded by enzymes with relatively broad substrate specificities, contrary to some reports that TRH was degraded by TRH-specific enzymes. Extensive enzyme characterization studies by Bauer et al. clearly demonstrated that the deaminidation of TRH is not catalyzed by a specific "TRH-deamidase" but by a post-proline cleaving enzyme. This enzyme hydrolyzes a variety of neuropeptides at internal proline-x bonds. The hydrolysis of TRH at the pyroGlu-His bond was found to be catalyzed by an enzyme which had been characterized previously as a pyroglutamate aminopeptidase. This enzyme hydrolyzes a variety of pyroglutamyl-containing peptides such as neurotensin, gastrin, and luteinizing hormone releasing hormone (LH-RH) as well as synthetic substrates, specifically at the pyroglu-x bond. Subcellular fractionation studies demonstrated that both enzymes are present almost exclusively in the cytosolic fraction. These studies also revealed the existence of another plasma-membrane bound enzyme (Ep) which hydrolyzes TRH-His at the pyroGlu-His bond. It differs from the cytosolic pyroglutamate in various physical and chemical properties. Previously, a TRH-degrading serum enzyme (Es) had been characterized by Bauer et al. which exhibits almost identical characteristics with the membrane-bound enzyme. Moreover, and of most importance, the TRH-degrading serum enzyme and the plasma membrane-bound enzyme exhibit a high degree of substrate specificity unlike the pyroglutamate aminopeptidase. It is possible that Ep and Es represent membrane-bound and secreted

forms of the same gene product. This is currently under investigation in order to evaluate the relationship between these enzymes.

The observation that, in the rat, the activity of the TRH-degrading enzyme seems to be controlled by thyroid hormones and drastically alters with developmental changes furthermore suggests, according to Bauer et al., that these enzymes (Es and Ep) might serve very specific functions. Hypothetically, the serum enzyme may represent a functional control element since degradation during transport by the hypophyseal portal blood might influence the amount of TRH which becomes available at the trophic cells of the pituitary. The membrane-bound TRH-depending enzyme might potentially fulfill a specific function for the degradation of TRH at the target sites. In this context, it is noteworthy that TRH has also been found in extrahypothalamic brain areas. Since high-affinity receptors for TRH have been demonstrated in these structures, the existence of an effective inactivation mechanism would be a prerequisite for the suggested function of TRH as a neuromodulator or neurotransmitter at these sites. Recent studies with murine cells in primary culture support this hypothesis. After addition of radiolabeled TRH to the culture media, Bauer et al. found that TRH is rapidly degraded by neuronal cells but only very slowly by glial cells in primary culture. First of all, these results demonstrate that this TRH-degrading enzyme is localized at the extracellular site of the plasma membrane. Furthermore, the heterogeneous distribution of this enzyme between neuronal and glial cells indicates that this TRH-degrading enzyme is not a general membrane-constituent protein and thus suggests that it may serve more specialized functions. Evaluation of the biological function of the TRH-degrading serum and plasma membrane-bound enzymes is currently being investigated by Bauer et al.

Degradation of Luteinizing Hormone-Releasing Hormone (LH-RA)

The rapid degradation of LH-RH by brain and pituitary homogenates has been attributed to the action of LH-RH-specific peptidase. Subsequently, it has been suggested on the basis of very preliminary studies that the activity of this enzyme is regulated by steroid hormones through feedback-regulatory mechanisms and therefore it has been postulated that this enzyme might act as a functional control element. However, the characterization by Bauer et al. of the TRH-degrading enzymes showed that LH-RH is not only degraded by one enzyme but is also subject to degradation by the pyroglutamate aminopeptidase (E_1) and the post-proline cleaving enzyme (E_2). In addition, other enzymes capable of degrading LH-RH have been found by Bauer et al., namely: a nonchymotrypsin-like endopeptidase (E_3), a cation-sensitive neutral endopeptidase (E_4) and a particulate LH-RH-degrading enzyme (E_5) which cleave the decapeptidamides at multiple sites. Very recently, it has been reported that LH-RH is also degraded by angiotensin-converting enzyme (E_6), primarily by hydrolyzing the Trp-Ser and Leu-Arg bonds.

A specific LH-RH-degrading enzyme, however, has not yet been identified. Subcellular fractionation studies with rat adenohypophyseal homogenates demonstrated that the particulate LH-RH-degrading enzyme is located in the mitochondrial matrix space, while the other enzymes (E_1-E_4) were found in the cytosolic supernatant. From these studies, no evidence could be obtained for the existence of a plasma membrane-bound LH-RH-degrading adenohypophyseal enzyme. Since enzyme activities might have been lost during the subcellular fractionation procedures, Bauer et al. also investigated the degradation of LH-RH by dispersed pituitary cells in culture. In confirmation of their subcellular fractionation studies, Bauer et al. did not find any significant degradation LH-RH by intact pituitary cells. These results suggest that, at the pituitary level, other inactivation mechanisms might exist; for example, the receptor-mediated endocytosis which could be adequate for cleaving LH-RH target sites, since LH-RH is known to be released in a pulse-type fashion with very low frequency in the range of 1 to 2 hours. Whether this is also true for the inactivation of centrally acting LH-RH is being studied by Bauer et al.

Degradation of Enkephalin

Due to their unprotected amino-and-carboxy terminals, enkephalins are subject to extremely rapid degradation by various exopytidases. This feature accounts for the short half-life of these pentapeptides. The removal of the amino-terminal tyrosine and thereby the inactivation of the pentapeptides is catalyzed by a variety of as yet not fully characterized aminopeptidases. In all systems studied so far, tyrosine was always found as the major metabolite of enkephalin degradation.

The observed fragmentation of the enkephalin at the Gly-Gly bond has been reported to be catalyzed by a membrane-bound dipeptidyl aminopeptidase

(enkephalinase B) which seems to be very similar to a cytosolic aminopeptidase III. Bauer et al. purified these two enzymes to homogeneity and obtained identical molecular weights of 83,000 and very similar enzymechemical characteristics indicating that both enzymes are the same. The cleavage of the pentapeptides at the Gly-Phe bonds is catalyzed by angiotensin-converting enzyme (dipeptidase carboxypeptidase), and initial studies had indicated that this enzyme might be specifically involved in the regulation of enkephalinergic transmission. However, extensive studies by several laboratories, including that of Bauer et al., demonstrated that enkephalinase was apparently identical to a thermolysin-like neutral metalloendopeptidase originally identified by M.A. Kerr and A.J. Kenny in 1974.

Subcellular fractionation studies demonstrated that enkephalin-degrading aminopeptidase, the dipeptidyl aminopeptidase, the thermolysin-like metalloendopeptidase and the angiotensin-converting enzyme are all associated with the plasma membrane. In a broad sense, all these enzymes could be regarded as potential "enkephalinases." However, by screening neuronal and glial cells in primary culture for enkephalin-degrading activities, Bauer et al. found only trace amounts of angiotensin-converting enzymes with these cultures. In agreement with this result is the observation that angiotensin-converting enzyme is mainly associated with the endothelial cells. The rapid degradation of Leu-enkephalin by glial and neuronal cells in primary culture is mainly due to bestatin-sensitive aminopeptidases. The dipeptidyl aminopeptidase activity is much higher in the neuronal than in the glial cultures whereas the opposite is true for the thermolysin-like metalloendopeptidase. Although the structural and functional integrity of cell interaction is not conserved in primary cultures, the present result suggests that in the case of the enkephalins, the bestatin-sensitive aminopeptidases on nerve cells could potentially be involved in the removal of enkephalins from the synaptic cleft, whereas the "enkephalinase" of glial cells or the angiotensin-converting enzyme on endothelial cells may hydrolyze peptides which already left the synaptic cleft by diffusion and therefore may serve general scavenger functions.

Degradation of Substance P

Substance P is widely distributed in the central and peripheral nervous systems and seems to be involved in neurotransmission and other forms of cellular communication. Little is known about the inactivation of substance P although a number of enzymes capable of degrading this peptide have been reported to exist in the brain. Degradation of substance P is effectively catalyzed by the thermolysin-like metalloendopeptidase which hydrolyzes Glu-Phe, Phe-Phe and Gly-Leu bonds. However, since Bauer et al. found that this enzyme appears to be preferentially associated with glial cells in primary cultures, it seems unlikely that this enzyme plays an important role in the inactivation of substance P at the synaptic cleft. Recent studies with purified angiotension-converting enzyme showed that substance P is also degraded by this enzyme by hydrolyzing primarily the Phe-Gly bond. Based on extensive studies with a variety of peptide substances, this enzyme was characterized as a dipeptidyl carboxypeptidase, but Bauer et al. have found that this enzyme may also exhibit endopeptidasic activities. Due to its preferential association with endothelial cells, however, angiotension-converting enzyme may fulfill general scavenger functions, but does not seem to be a potential candidate as an enzyme serving specialized target site clearance functions. Thus, it seems unlikely that the enzymes characterized so far participate in inactivating extracellular substance P in the synaptic cleft.

This notion is supported by studies by Bauer et al. on the degradation of substance P by glial and neuronal cells in primary culture. With these cells, Bauer et al. observed rapid degradation of substance P, which was reduced only 30 percent when the culture medium was supplemented with a combination of inhibitors of the aforementioned enzymes. In contrast, the degradation of substance P was inhibited most effectively by the addition of bacitracin as the only enzyme inhibitor. Since the specific activity of this bacitracin-sensitive substance P-degrading enzyme is nearly fivefold higher in the neuronal than in glial cell cultures, these results suggest that this enzyme is probably the best candidate as a peptidase likely to be involved in the synaptic inactivation of substance P. Because the cell cultures do not contain functional synapses, immunohistochemical and cytochemical studies are needed to evaluate this hypothesis. It is necessary to isolate and to characterize this bacitracin-sensitive, substance P-degrading enzyme. Bauer et al. are presently carrying out such studies.

Biochemical studies by Bauer et al. as well as by other research groups have not revealed any evidence for the

presence of neuropeptide-specific enzymes in the brain or the pituitary. The primary specificity of the enzymes identified in these tissues is, rather, directed toward certain structural elements of the peptide (e.g., the amino-terminus or an amino acid side chain, etc.). This does not exclude the possibility, however, that the rate of hydrolysis of a given peptide bond is strongly influenced by neighboring groups and the size and conformation of the substrates. The Km values are in the micromolar range as expected for general peptidases. Potentially, such enzymes are capable of degrading an unlimited number of peptides provided that they contain the appropriate structural elements. Bauer et al. think that it is clear that these enzymes, which lack the specificity and selectivity required for a regulation process, cannot fulfill a regulatory function themselves. Therefore, the concept that neuropeptide-degrading enzymes directly serve a dynamic control function cannot be correct. The more specific target site clearance function of the neuropeptide-degrading enzymes--and eventually their function as local converting enzymes--is primarily governed by the strategic localization of the enzymes in relation to a given pathway. Therefore, it will be most important to determine at the electron microscope level the exact localization of the individual enzyme in relation to a given peptidergic terminal. Only at this level, according to Bauer et al., is it possible to obtain information as to the biological function of a given peptidase for the inactivation of a specific peptide at a specific site. For such studies it is necessary to purify the peptidase to homogeneity and to raise enzyme-specific antibodies for the imminohistochemical studies. Bauer et al. are presently engaged in such studies as well as in characterization of the neuropeptide-degrading enzymes to provide the basis for the design and synthesis of enzyme-resistant analogs suitable for psychological and pharmacological investigations.

Carnosine and Related Peptides

Although carnosine (β-alanyl-histidine) and related peptides (ω-aminoacyl amino acids) have been known for many years as constituents of excitable tissues, brain, and muscle, virtually nothing is known of their function. Furthermore, there is also no information available as to the localization of the enzymes involved in the metabolism of these peptides. All ω-aminoacyl amino acids are apparently synthesized from their constituent amino acids by only one enzyme with very broad substrate specificity: carnosine synthetase. Hydrolysis of ω-aminoacyl amino acids, however, seems to be catalyzed by various highly specific enzymes which have not yet been fully characterized.

By screening various cell lines, Bauer et al. have observed that carnosine is actively synthesized by the rat C_6 glioma cell line but not by neuroblastoma cell lines or cell lines originating from hypothalamic neuronal cell cultures. With brain cells in primary cultures, synthesis of ω-aminoacyl amino acids could only be observed with undifferentiated glial cells in primary culture (astroblasts) but not by neuronal cells in primary culture or by differentiated glial cells (which exhibit astrocyte-like morphology) as obtained by treatment with dibutyryl cyclic AMP. Bauer et al. are carrying out studies to test whether the observed inhibition of carnosine synthesis is directly and causally related to the processes leading to the morphological differentiation of glial cells in primary culture. These researchers have also purified carnosine synthetase from chick pectoral muscle about 1500-fold which has been used in their studies of the biosynthesis of carnosine and other ω-aminoacyl amino acids. Bauer et al. are also studying the degradation of these amino acids using highly purified preparations of the degrading-enzymes such as carnosinase. Their working hypothesis is that studies on the metabolism of carnosine by cultured cells might help to study the mechanisms of cellular communication and the processes of cellular differentiation and to understand the yet-unknown biological function of ω-aminocyl amino acids in excitable tissues.

Biosynthesis of Antibiotic Peptides

H. Kleinkauf and his group have been studying the biosynthesis of antibiotic peptides for several years and were one of the first research groups to carry out extensive studies in this area. Peptide antibiotics are produced by a variety of micro-organisms and it has been shown by Kleinkauf et al. as well as others that these peptides are synthesized by enzymatic mechanisms rather than by the ribosome-transfer RNA-messenger RNA (polysome) system, which is the biosynthetic machinery for the synthesis of proteins (polypeptides). The antibiotic peptides are often cylic, and analog-type substitutions of individual residues are very common. In addition, residues other than the 20 or 30 L-α-amino acids found in proteins are frequently present,

including D-amino acids, hydroxy acids, and fatty acids. The biosynthesis of antibiotic peptides represents a more primitive method of producing a programed sequence of amino acids than the more complex ribosomal system which evolved during the course of biochemical evolution.

Kleinkauf et al. have carried out extensive studies on the mechanism of the biosynthesis of the cyclic decapeptide gramacidin S (GS) as well as tyrocidine (Ty), edeine, and malformin by various strains of *Bacillus brevis*. Kleinkauf et al. found that the formation of antibiotic peptides such as Gs, Ty, linear gramicidins, and edeines by *B. brevis* strains proceeded on multienzyme complexes. The constituent amino acids are activated on protein sites comparable to those of aminoacyl-tRNA synthetases of the ribosomal system. The noncovalently bound aminoacyladenylates are transferred to the thiol groups instead of hydroxyl groups of transfer RNA. Peptide bond formation occurs from thiolaters in four types of reactions: initiation, elongation, transfer, and termination.

One of the first multienzymes isolated and characterized by Kleinkauf et al. was Gramacidin S-synthetase of 280,000 molecular weight. This enzyme catalyzes activation of the amino acids proline, valine, ornithine, and leucine as aminocyl adenylates which are transferred to thiols. By interaction with phenylalanine racemase, peptide snythesis is initiated with the formation of D-phenylalanyl-proline which remains linked on the multienzyme. Subsequent peptidyl transfers to 4'-phosphopantetheine and from the cofactor to the specific amino acid give rise to pentapeptidase enzyme-S-Leu-Orn-Val-Pro-D-Phe which combine antiparallel to the symetric decapeptide Gramicidin S.

Kleinkauf et al. have found that enniatins (cyclic depsihexapeptides) with antibiotic properties are produced by various strains of *Fusarium* and that the biosynthesis also occurs by nonribosomal mechanisms. Some other antibiotic peptides synthesized by nonribosomal mechanism are alamethicin, valinomycin, actinomycin, and carnosine (mammalian tissues).

It is now evident that secondary metabolites, especially peptide antibiotics can be produced by soluble multienzyme systems. Almost all antibiotics are routinely isolated from cultures of micro-organisms. Purification procedures have to be applied to either fermentation broth or cell extracts, and complex mixtures of products are frequently obtained. When it became apparent that multistep biosynthetic processes of complex compounds like peptide antibiotics may proceed on stable multienzyme systems, Kleinkauf et al. studied the possible synthetic applications of these enzyme catalysts. The purpose of enzyme applications to peptide synthesis is not only to compete for fermentation products but also to produce antibiotics not available from living cells or available only in complex mixtures of isomers. Two general principles are used: (1) the broad substrate specificity for substitution of various synthetic amino acid analogs and elimination of possible side reactions like cyclodipeptide formation by Gramicidin S-synthetase when the third amino acid is omitted; (2) defined substrates always yield defined products and no complex separation procedures have to be applied. Actions of analog-substituted peptides will be similar to the parent compound. Thus, the aim of Kleinkauf and his group is to use the information obtained from their studies of the biosynthesis and metabolism of antibiotic peptides to prepare these peptides using defined *in vitro* systems instead of the cumbersome extraction of these peptides from fermentation of the relevant organisms. The main advantage of cell-free systems is the controlled formation of products which eliminates separation procedures. The unique multistep mechanism eliminates byproducts caused by incomplete peptidation reactions as observed in chemical peptide synthesis. The biosynthetic process for forming antibiotic peptides such as bacitracin, Gramicidin S, linear gramicidin, polymyxins, and tyrocidines is now termed the multienzyme thiotemplate mechanism.

Kleinkauf et al. are also studying the functions of the antibiotic peptides. They have found that bacitracin (*Bacillus licheniformis*) is involved in cation transport (n^{2+}, Co^{2+}, Zn^{2+}) and can also act as an enzyme inhibitor whereas linear Gramicidin S, a neutral surfactant, is involved in the forming of membrane channels and the transport of the cations K^+, Na^+ and Li^+. Gramacidin S is a cation surfactant and is involved in the inhibition of membrane-associated functions of the spore membrane; it acts as a germination effector, an enzyme inhibitor, and as an inhibitor of transport functions Tyrocidines are cationic surfactants and also bind to DNA, thereby affecting transcription.

Conclusion

The researchers at the Institute for Biochemistry and Molecular Biology, Technical University of Berlin, have

been very productive even though the institute is only about 10 years old. The main research emphasis is on studies of biologically active peptides from bacterial sources (antibiotic peptides) and mammalian sources (neuropeptides). The institute has several projects supported by industry as collaborative programs.

4/8/86

Computer Sciences

ARTIFICIAL INTELLIGENCE ACTIVITIES AT BRISTOL'S NEW INFORMATION TECHNOLOGY RESEARCH CENTER

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

Projects ranging from creation of a fuzzy-logic knowledge base to expert systems for threat evaluation are vigorously pursued at a remarkable, only 2-year-old interdisciplinary center located at Bristol University, UK. Within that broad range its scientists are working on such projects as object identification, speech recognition, support-logic programing for relational information languages, and expert systems for intelligent maintenance/fault diagnosis--all further evidence of the vigor and creativity of this center.

Background

The Information Technology Research Center grew out of a joint venture between the Department of Computer Science, the Microelectronics Group of the Department of Electrical and Electronic Engineering, and the Artificial Intelligence Group (AI) of the Department of Engineering Mathematics. Today it also has programed relations with work done in the School of Mathematics, the Civil Engineering Department, and the Brain and Perception Group of the Anatomy Department, as well the Departments of Psychology, Philosophy, and Architecture. It has an academic staff of 26 scientists, who also have duties in their specific home departments. The Science & Engineering Research Council (SERC) and various private industries support, in addition, a full-time research staff of six people as well as over 20 postgraduate research students. The center has 11 "industrial partners" (including British Aerospace, British Telecom, Marconi Space & Defence Systems, and the Admiralty Research Establishment at Portland) and currently enjoys well over $1 million of external grant support. One of the major contracting agencies is the Alvey Program, in cooperation with SERC.

Currently the center has four active study groups:

- Artificial intelligence
- New computer architectures and VLSI design
- Software engineering
- Robotics.

Future plans also include more focused studies in intelligent computer aided design (CAD) systems.

This brief review surely shows that the center deserves much attention; however, because of my current fields of interest, I will report only about my recent visit to the Artificial Intelligence Group, chaired by Professor J.F. Baldwin.

General Description of the AI Group

The AI Group evolved from research interests in decision theory and control theory, fuzzy sets theory, and uncertainty logics. Fundamental research in knowledge representation, deductive inference, and logic programing (very popular British approaches) as well as uncertainty and machine learning emerged more recently. Close ties with industry resulted in various applications of expert systems (ES), and interest in the problems of vision understanding led to the group's participation in the Alvey project whose goal is object identification from two-dimensional images. A second Alvey project is concerned with developing AI tools for writing an ES to maintain a telephone exchange network.

The current list of active research topics in the group is as follows:

- Fuzzy Prolog
- Fuzzy relational inference language
- Conceptual graphs
- General theory of uncertainty
- New approaches to human inference and theorem proving
- Applied research (maintenance, monitoring, ES for tactical weapon systems, decision classification/discrimination methods for medical diagnosis).

I will briefly survey the first two topics.

Fuzzy Prolog (FP). This is essentially a Prolog system which includes a general fuzzy-logic inference mechanism and also an interface to FRIL (see below).

Predicates in FP have an extra argument called "chi value," which represents the uncertainty measure associated with the satisfaction of the predicates. The user has the choice of developing the calculus that combines chi values associated with different relations. Thus, various multivalued logics can be used, including familiar ones from the theory of fuzzy logics. Path analysis problems can be treated by interpreting the chi value as a distance between nodes in a graph, so that the shortest route problem can be derived by simply using a plus-operator for conjunction and a minus-operator for disjunction. The chi value can also be used as a measure of the difficulty of proving the satisfaction of a given predicate, and thus it may control the backtracking of Prolog.

Fuzzy Relational Inference Language (FRIL). This ES language is the pride of Baldwin and his principal associate, Dr. B.W. Pilsworth. It was produced at the center as a result of fundamental research in inference and uncertainty logic.

FRIL has a syntax similar to Prolog in that it uses a data base of facts in the form of tables and rules; but it answers querries more in the style of a relational data base, using algebraic operations (such as join, project, select, union, intersection, and so on). FRIL's inference mechanism is based on breadth search, rather than depth search as done in Prolog. Each new concept is defined by a rule and is compiled to procedural code.

FRIL employs measures of uncertainty that propagate through the operations. The support logic programing system uses a theory of "support pairs" to model various forms of uncertainty. The logic programing style of inference embodied in FRIL (and to be developed further in the near future) does not rely upon a "closed world" form of knowledge representation. That is, it is not assured that facts not present in the database are necessarily false. Instead, such a fact is given a "necessary support" value of zero and a "possible support" value of one. The pitfall of negation by failure is thus avoided.

FRIL is much more efficient than Prolog in answering fuzzy-logic and probabilistic queries; yet, as far as the user is concerned, it retains the programing style of Prolog. Nevertheless, FRIL is more restricted than Prolog by its limited form of unification. Again on the positive side, the FRIL mechanism contains an easy interpretation of both the AND and OR parallelisms; this will be a substantial advantage in future implementations on parallel machines. In particular, plans are now developed to use the OCCAM language as a vehicle to explore the potential for concurrency in knowledge engineering languages to be used in new parallel computer architectures. Work is in progress to implement FRIL in OCCAM and run it on an array of the new Inmos transputers.

Concluding Remarks

Even within the narrow bounds of its selective coverage this article could not do justice to this new, very lively, well-supported research center. As I see it, the center's strength comes from its breadth of organization, which was deliberately created to foster continued basic research on a firm platform of intellectual enterprise; it also utilizes to the utmost the industry/government/university triad--a form of development so much spoken of yet rarely realized effectively. I wish to add a word of praise regarding the modesty of the colleagues I met: this is not an accustomed trademark in the area of AI.

3/5/86

Mechanics

FLUID MECHANICS AT NLR

by Eugene F. Brown. Dr. Brown is the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1987, from the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

The National Aerospace Laboratory (NLR) is the center for aerospace research in the Netherlands. It is located at two sites: in Amsterdam itself and approximately 100 km from Amsterdam in the Northeast Polder. At the present

time the administrative headquarters and the majority of NLR's approximately 780 employees are located in Amsterdam. Since acquiring the 500-acre site in the Northeast Polder in 1958, however, activities have gradually shifted from Amsterdam. At the present time several departments of the Fluid Dynamics Division as well as the German-Dutch Windtunnel (DNW) are located there. My visit was to the site in Amsterdam.

NLR had its origins in 1913 with the formation of the Aeronautical Department of the Dutch Navy. It was organized into its present form as an independent, nonprofit organization in 1937. NLR's principal mission is to render scientific support and technical assistance on a nonprofit basis to Dutch and foreign aerospace industries and organizations, civil and military aircraft operators, and government agencies concerned with aviation and space flight. NLR closely cooperates with the Dutch aircraft manufacturer, Fokker, in aircraft development under contract with the Netherlands Agency for Aerospace Programs (NIVR). In fact, Fokker depends entirely on NLR for scientific support. In addition, NLR assists Dutch aircraft operators (KLM, the Royal Netherlands Air Force, and the Royal Netherlands Navy) with the evaluation of aircraft and equipment and with technical problems in aircraft operations. For the Royal Netherlands Air Force, it operates a scientific research program planned on a rotating 5-year basis in the field of aeronautics. Finally, NLR contributes to the development of Dutch aerospace projects and projects for the European Space Agency and foreign aerospace industries.

At the present time approximately 70 percent of NLR's income is derived from research contracts and the remainder from subsidies from the Dutch government. Much of its current contracted activities are directed toward the needs of Fokker in support of its new F-50 and F-100 commercial aircraft development projects. Incidentally, this work is funded by the NIVR; however, because Fokker is a private company, this money must be repaid out of the company's profits.

The Fluid Dynamics Division performs a considerable amount of experimental studies for European industrial concerns and foreign governments. For example, approximately one-third of the aerodynamic work on the Concord was done in its Transonic Wind Tunnel (HST) located in Amsterdam. In addition, a large number of acoustics and aerodynamic studies for various European automobile manufacturers have been conducted in the DNW. At the present time tests are being conducted there for the US Navy's LHX helicopter program under the provisions of the Patriot Compensation Program. The large size of the DNW's test section (9.5×9.5 m^2) allows full-size automobiles to be rolled into the tunnel for testing.

The Fluid Dynamics Division

NLR is organized into five major divisions including: Fluid Dynamics, Flight, Structures and Materials, Space, and Informatics Divisions. My visit was to the Fluid Dynamics Division. As can be seen from the NLR organizational chart, Figure 1, the Fluid Dynamics Division is divided into six departments: Incompressible (Low-Speed) Aerodynamics, Compressible (High-Speed) Aerodynamics, Propulsion Aerodynamics, Aeroelasticity, Theoretical Aerodynamics, and Wind Tunnel Instrumentation. In addition to the HST and the DNW, the Fluid Dynamics Division operates a 3×2.25-m^2 Low-speed Wind Tunnel (LST) and a Supersonic Wind Tunnel (SST) located in Amsterdam.

My host for my visit was Dr. H. Tijdeman, the Head of the Fluid Dynamics Division. After a brief review of the other departments, the discussion turned to the Fluid Dynamics Division which, at the present time, consists of a staff of 150, split about equally between Amsterdam and the Northeast Polder. Approximately one-third of the staff have masters or doctoral degrees. The remainder are technical and service staff.

Two departments within the division are located in the Northeast Polder: the Incompressible Aerodynamics Department, and the Propulsion Aerodynamics Department. The Incompressible Aerodynamics Department is responsible for tests conducted in the LST and DNW tunnels plus an acoustics facility. Industrial, aircraft, ship, and automobile aerodynamics and acoustics tests are run by this group. An interesting Navy project was the aerodynamic tests of helicopter carriers in order to determine safe landing conditions. This was done for the Dutch and Norwegian navies.

The Propulsion Aerodynamics Department is responsible for aerodynamic and acoustic tests involving propulsion system integration in which it often runs tests involving powered engine simulators. At the present time such tests are going on to determine the aerodynamic and acoustic characteristics of a new six-bladed propeller for the Fokker F-50. In a proposed transonic extension of this work it is hoped that, with careful blade design, a high-performance, straight-bladed propeller capable

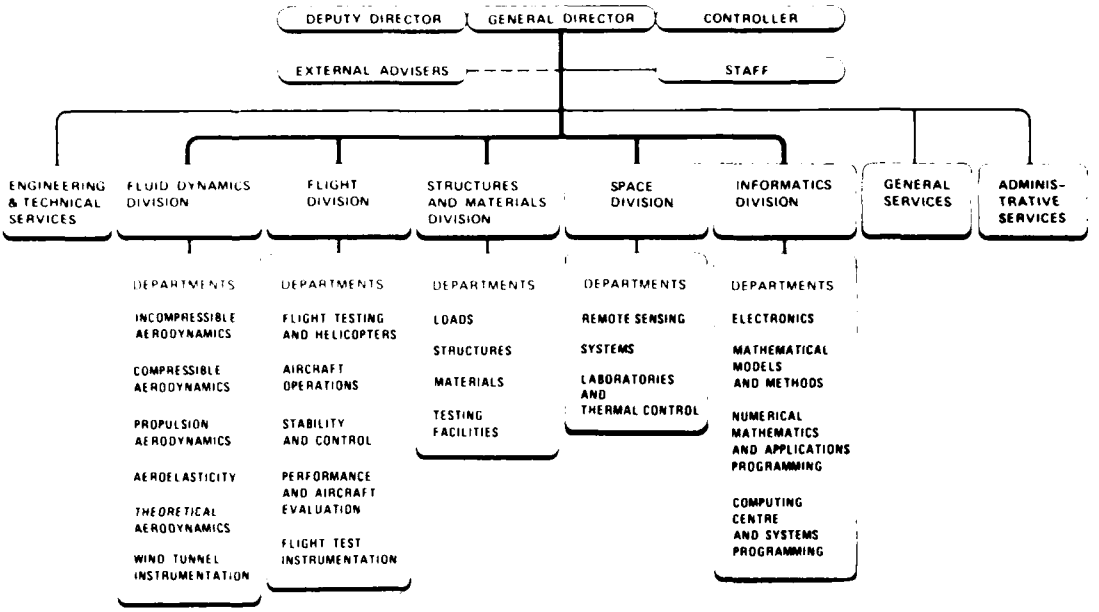


Figure 1. NLR organizational chart.

of efficient operation at high Mach numbers can be built.

The Compressible Aerodynamics Department is located in Amsterdam. Its two principal experimental facilities are the HST and the SST. The HST is one of the principal aerodynamic facilities in Europe. It is a pressurized tunnel capable of stagnation pressures between 0.1 and 4 atmospheres and Mach numbers up to 1.25. Its test section is 2.0×1.6 m^2 and is compatible with that of the SST (1.2×1.2 m^2); this enables the same model to be tested both in the HST and SST and gives NLR the unique capability of being able to carry out tests of the same model from incompressible conditions up to a Mach number of four.

The Aeroelasticity Department, also located in Amsterdam, is involved in both computational and experimental unsteady aerodynamics and flutter research. The group has carried out steady load measurements on the F-5 wing for the Air Force Wright Aeronautical Laboratories (AFWAL) and NASA and has made elasticity measurements on industrial structures such as bridges and dikes. They are presently carrying out pitching tests on the F-16 wing for General Dynamics (GD), Fort Worth, and AFWAL. These tests, which are scheduled to take place over the next 22 months, were described to me by Dr. Atlee Cunningham from GD who just happened to be at NLR during my visit. The tests will be carried out in the LST and will feature both small-amplitude, high-frequency oscillations typical of structural vibrations and large-amplitude, low-frequency oscillations typical of maneuver operation. Static pressure data will be taken with 42 pressure taps and loads will be measured with a six-component balance. Initial tests are planned at a Mach number of 0.3 with a series of follow-on tests to be conducted at transonic Mach numbers. The purpose of the project is to examine the vortex bursting phenomenon which occurs on wings of delta planforms at high angles of attack and high Reynolds numbers. These tests will be conducted with a mean angle of attack of 55 degrees. Because the vortex bursting phenomenon is poorly understood, extensive flow visualization studies using a pulsed laser sheet as well as global lighting have been planned to visualize the flow in cross-section over the entire wing. Although the ultimate objective of this work is to learn how to control vortex bursting at high Reynolds numbers, the immediate application of this work is to develop and improve Euler codes which are being written to predict the vortex bursting phenomenon

Cunningham has an ONR contract to look at vortex bursting in a smoke tunnel and a 2×2 ft^2, high-speed water tunnel which is currently being built at GD. Eventually the results of the small-scale tests at GD will be compared with the NLR tests to investigate the effects of Reynolds number on vortex bursting.

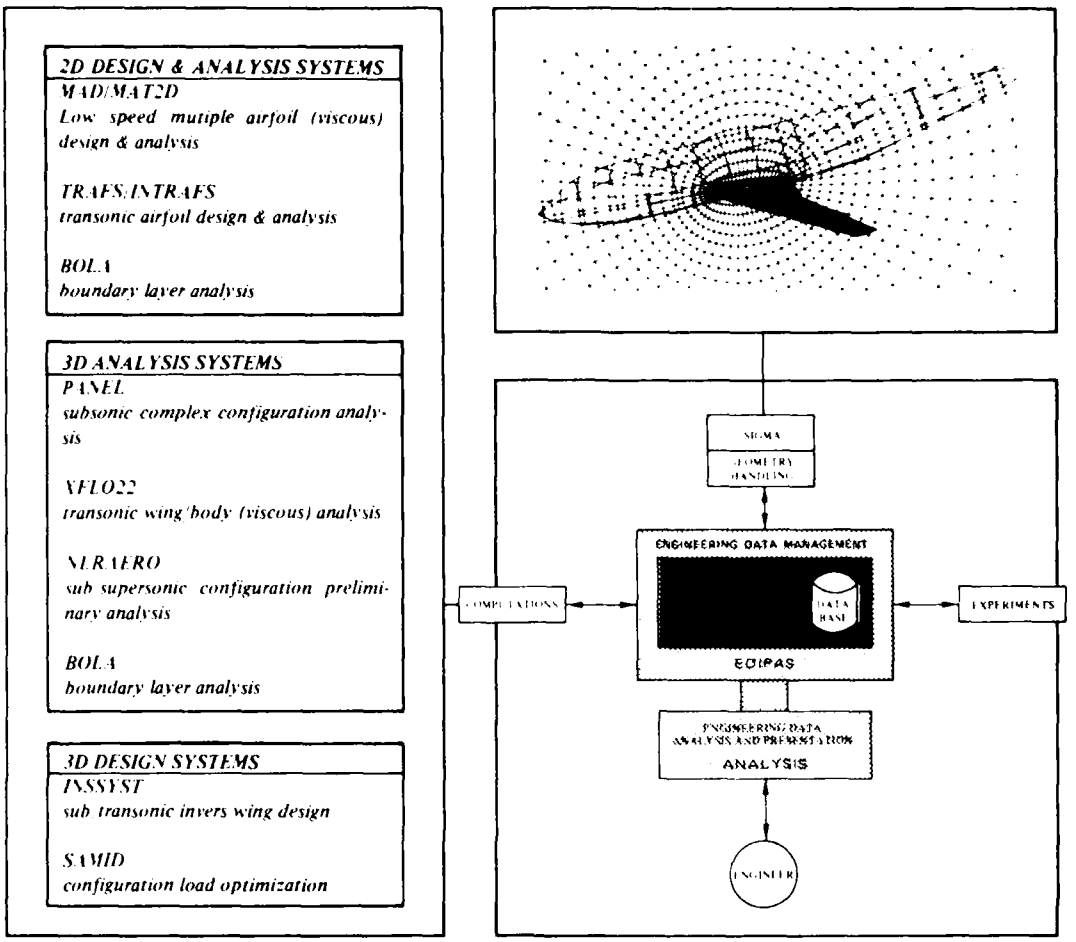


Figure 2. Computational fluid dynamics programs.

NLR's Computational Fluid Dynamics Work

The bulk of the computational fluid dynamics work at NLR is conducted in the Theoretical Aerodynamics Department, which is headed by Mr. J. Slooff. At the present time he has a staff of 10, complemented by a group of approximately equal size in the Informatics Division which supports his activities in the areas of mathematical models and numerical methods. Slooff's group is responsible for writing analysis and design codes to support Fokker's aircraft production activities and to sell to other aircraft companies. In this latter connection they have developed codes for low-speed, multiple airfoil design; transonic airfoil design; boundary layer analysis; three-dimensional panel methods for complex subsonic configuration analysis; and inverse wing design. Figure 2 gives a schematic indication of the Division's computational capabilities. Some of the most important new work involves the modeling of surface waves, viscous/inviscid interactions, a new multigrid concept for panel methods, and a new field panel method.

NLR's principal computational facility is a Control Data Corporation (CDC) Cyber 180/855 mainframe computer supplemented by a link with a Cyber 205 at the University of Antwerp. Slooff said that the link was not very good and that he felt handicapped by the small memory size (1 megabyte). This situation should improve considerably, however, in the 1988-1989 time frame since NLR plans to purchase a Cray X-MP with a 2 megabyte memory and additional solid-state device (SSD) storage.

Slooff's close ties with Fokker have advantages and disadvantages. The advantage is, of course, that Slooff (through NIVR) is assured of a steady income. The disadvantage is that the activities of his group are highly constrained. For one thing, Fokker's

interest is primarily in civilian aircraft, thus most of Slooff's work must be in connection with civilian rather than military projects. In addition, the intense activity at Fokker in connection with the new F-50 and F-100 projects has demanded so much of Slooff's time that his group has fallen behind in the development of new algorithms. This explains why his group has very little Navier-Stokes work going on and got started fairly late in the development of its three-dimensional Euler code.

Slooff is perhaps best known for his panel method calculations for wing design which he began in 1968. Since that time many refinements in the code have been implemented. In its present second-order-accurate form, it contains advanced singularity formulations and use of Dirchlet rather than Neumann boundary conditions. A multigrid capability has also been added which can be implemented either as a conventional accelerated convergence technique or as a means to reformulate the equations themselves. To reformulate the equations, grids of successively finer size are proposed leading to a banded matrix for the aerodynamic influence coefficients (AIC's). The banded nature of the matrices for the AIC's leads to significant savings in both storage and computational time. The initial estimates are that this technique will allow a panel method simulation to be worked out with N operations. This compares with N^3 operations which are required for present classical methods employing Gaussian elimination. If these estimates are correct, this means that computational time savings of several orders of magnitude can easily be achieved. Slooff calls this a multilevel integral evaluation (MIE) technique. A feasibility study has been completed which demonstrates the efficiency of the technique on a flat-plate airfoil problem.

Another new development is the use of field panel methods to calculate the compressible flow over the slats of a multi-element airfoil in the low-speed (Mach=0.2) takeoff and landing configuration. In these situations it has been found that Mach numbers as high as 1.6 exist on the slat which, combined with a resulting shock wave, invalidate the incompressibility assumptions inherent in classical panel methods. To simulate the essential nonlinearity of the compressible flow, the region on almost the entire suction surface and, in some cases, half of the pressure surface is surrounded by a C grid. In this region the distribution of source singularities is found by solving the full (compressible) potential equation by a fully conservative, finite volume technique. In the remainder of the flow, the conventional (incompressible) panel method is used. The resulting solution is therefore a combination of the field singularity distribution obtained on the grid and the surface distribution of singularities on the airfoil surface computed by the conventional panel method. Osher-type splitting combined with a multigrid method was used to accelerate the convergence of the field calculations. The advantage of the technique is that nonlinear simulation is attempted only in those regions of the flow field where compressible effects are expected. This has two advantages: it reduces the computational time and it simplifies the grid generation process. In the latter connection, this means that the complexities associated with generating and interpolating between the multiple grids used in conventional domain decomposition methods can be avoided.

In a recent article describing the field panel method, B. Oskam described the application of this method to a NACA 0012 airfoil and a four-component, high-lift wing (Oskam, 1985). The airfoil was discretized into 64 surface panels and a grid of 24×8 elements. Excellent agreement with finite difference calculations was seen. For the high-lift wing, the calculations were compared with experimental data and once again a good agreement was obtained except in the vicinity of the trailing edge where a strong shock (Mach=1.6) on the upper surface of the slat resulted in the separation of the boundary layer. Discrepancies with the experimental data were, therefore, not unexpected. Obviously, additional attention needs to be given to the shock-wave/boundary-layer interaction problem if accurate calculations are to be obtained in such cases.

The program has been given the acronym MATRICS. An extension of this method to three-dimensional flows is presently under way. Mesh generators for more complex configurations such as the flow around an entire aircraft are being developed in collaboration with the Swedish Aeronautical Research Institute (FFA).

Slooff is famous for his calculations for Australia II, the yacht which won the America's Cup for Australia in 1983. It was widely acknowledged that it was the keel design which was responsible for the yacht's success. Slooff's contribution was the development of a panel method code for predicting keel performance which allowed surface wave effects to be taken into account. Slooff began working on a problem related to these calculations in

1977 in support of a SWATH-type (Small Waterline Area Twin Hull) vessel for the Dutch Navy. (The design for the Australia II was, in fact, managed by the Netherlands Ship Model Basin [NSMB], now known as MARIN, in Wageningen to which Slooff was a subcontractor.) Because of the military implications of this work, the reports on Slooff's calculations have not yet been released. His calculations are based upon the wave modeling concepts developed by C. W. Dawson of NSRDC. However, Dawson's scheme works only for low Froude numbers, and Slooff found that it was necessary to introduce an upwinding scheme on the free surface in order to produce a stable calculation for the infinite number case which he was considering. Slooff's intention is to combine this new surface model with his second-generation panel method.

Sloof also plans to develop a calculation method for limited regions of incompressible vortical flow such as found on partially stalled airfoils. Slooff is proposing to use a panel method which includes the vorticity by means of a Klepch formulation.

Finally we discussed the Theoretical Aerodynamic Department's plans for extending their quasi-simultaneous calculations of strongly interacting viscous flow to three-dimensional geometries. In contrast with conventional inverse and semi-inverse schemes, the quasi-simultaneous approach features the use of an interaction law which represents a linearization of the relationship between the velocity at the edge of the boundary layer and the displacement thickness. This equation is used in conjunction with an inverse method for the boundary layer in such a way that the combined solution represents a solution of the complete equation of the inviscid and viscous flows. The advantage of this technique is an order of magnitude increase in speed over semi-inverse methods and an increase in speed of two orders of magnitude over inverse methods. In contrast with other interaction calculations this technique (developed by A. Veldmann) is valid for compressible (as well as incompressible) flow, has a more advanced turbulence model, and includes the y-momentum equation in place of the usual boundary layer assumption of negligible transverse pressure gradient.

Conclusion

As should be clear from this article, NLR is not a basic research establishment. It is, however, performing work related to numerical modeling and algorithm development for a wide number of aircraft- and ship-related problems. Proposed developments in the area of multigrid methods (MIE), and surface-wave and vortical-flow modeling might be worthwhile considering for future Navy support.

Reference

Oskam, B., *American Institute of Aeronautics and Astronautics Journal*, 23, No. 9, (September 1985), 1327-1334.

4/2/86

TURBULENCE RESEARCH AT THE DELFT HYDRAULICS LABORATORY

by Eugene F. Brown.

The Delft Hydraulics Laboratory (DHL) was founded in 1933 as an agency of the Netherlands government. Its activities are conducted both at its headquarters in Delft and at DeVoorst in the Northeast Polder. The total number of DHL personnel is 535. Approximately one-third of these have masters and doctoral degrees. The principal activity of the laboratory is coastal hydraulics, and it conducts research similar to that done at the French National Hydraulics Laboratory (LNH) in Paris (*ESN* 40-4:136-138 [1986]). In addition to its work in coastal, estuary, and fluvial hydraulics, it is involved in matters concerning water resources, the environment, and cutting and dredging technology. Some of the best known examples of its hydraulics work are its design of the flood barrier in the East Scheldt and its delta model of the Southwest Netherlands. It has several wave basins, flumes, wind-wave facilities, and pump testing circuits. For its saline intrusion work it has a seawater manufacturing facility capable of producing salt water with a specific gravity of up to 1.19.

As with LNH, DHL has a number of computer programs which it uses in its hydraulic studies. Some of these models are described in Figure 1. The program ODYSSEE was, in fact, jointly developed between LNH and DHL and is an example of the close cooperation which exists between these two laboratories.

There are a number of comparisons which can be drawn between the two organizations. First of all, in contrast with LNH, DHL has no finite element programs under development. The explanation offered by DHL for concentrating on finite difference rather than finite

Applicable computer programs

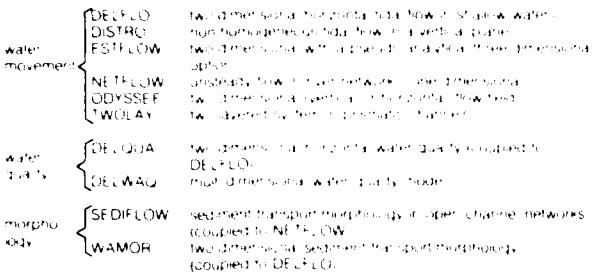


Figure 1. Hydraulics modeling programs at DHL.

element methods is that uncertainties in turbulence modeling are far greater than the inaccuracies introduced by failure to accurately specify the boundary conditions. Thus the greater accuracy which is provided by finite element methods in the handling of the boundary conditions is not all that important.

In addition, in contrast with LNH, DHL has no three-dimensional hydraulics simulation programs. This is at least partially due to the fact that its computational facilities are quite limited compared with those of LNH. In fact it has no mainframe computing facilities suitable for computational fluid dynamics calculations but uses, instead, links with a CDC Cyber 175 at the Dutch Energy Center (ECN), the CDC Cyber 205 at the University of Amsterdam, and a Cray at the Shell Research Center. Another reason is that the industrial hydrodynamic activities, which are likely to require such codes, are much more limited at DHL than they are at LNH. This is because DHL unlike LNH has no connection with the power generating industry. LNH's connection, of course, comes from its being a department of Electricité de France, the French electrical power generating monopoly.

My host at DHL was Mr. R. Uittenbogaard. Much of Uittenbogaard's current activities and plans for future research are in the turbulence modeling area. This is a result of a change of direction which has take place at DHL over the past few years. No longer does the construction of flood control barriers and dikes require the large-scale research activities it once did. The period of intense construction of these facilities in the Netherlands is past. Attention is therefore turning to sustaining the navigability and environmental quality of the waterways which have already been constructed. In particular, this means that attention is being given to problems of sedimentation and saline intrusion. Accurate prediction of these phenomena requires accurate turbulence models. Development of accurate turbulence models for the mixing of saline-stratified flows is currently the focus of Uittenbogaard's activities.

Uittenbogaard is a member of a 10-member team funded by the Department of Public Works and Transportation of the Dutch government to carry out experiments which will contribute to improvement in the ability to predict the mixing which occurs in saline-stratified flows. This is a 10-year program which is funded at the rate of approximately $2 million per year.

The experiments will be conducted in the new tidal flume facility which is just now nearing completion. Both mean and turbulence velocities as well as the position of the saline/fresh-water interface will be made. At the present time these data do not exist. Measurements will be made with both standard conductivity probes and a new fiber-optic laser probe.

The new laser probe is the result of an instrumentation development program which has lasted several years and has cost more than $100,000. The laser probe is a submersible reference beam anemometer in which only approximately 3 inches of the beam is exposed to the flow. A short optical path length in the flow is necessary to minimize the refraction effects which take place at the interface between the saline and fresh water flows. The advantage of the reference beam over the more familiar (in the United States) Doppler method is that two-component measurements can be more easily made. In addition, a low-power laser can be used, and photo diodes can be used in place of more delicate and expensive photo-multiplier tubes.

The new laser probe was designed by Dr. H. Godefroy, who also designed the signal processing equipment. The signal processor is basically a frequency tracker which operates in parallel with a counter in order to overcome the small capture-range restrictions (range in which the signal is regained after a short interruption) of a conventional tracker.

The construction of the second-generation prototype is now nearing completion. It features lenses with antireflection coatings and a somewhat more powerful laser (6 mW instead of 2 mW) in order to enable measurements to be made under poorly seeded conditions. A modification has also been made so that the laser beams cross the flow in a horizontal rather than vertical plane. This allows measurements closer to horizontal

(top and bottom) surfaces to be made and also allows for velocity measurements in the vertical plane.

Uittenbogaard and his coworkers are planning a detailed study of the turbulence mechanisms in saline-stratified flows. In such flows, buoyancy effects result in a damping of the vertical component of the turbulence velocity and a resulting decrease of mixing in the vertical plane. This is accompanied by a corresponding increase in mixing in the horizontal plane, and turbulence models must account for this. He feels that the so-called Reynolds stress turbulence model offers the best chance of accurately calculating such flows. He hopes to use the data obtained from Godefroy's laser probe and small catheter-sized microphones to modify the pressure/strain correlation contained in such models. Attention will be focused on the downstream mixing characteristics where the vertical turbulence velocity is nearly zero and the interface has assumed a wavelike structure. Of particular interest here will be the stability of the interface surface and the persistence of any structure produced by the manner in which the streams were initially mixed. He also intends to study the intermittent bursts which accompany the mixing process. Eventually, Uittenbogaard hopes to use his work on the Reynolds stress model to improve the performance of the k-ε model, which he views as being more suitable for engineering calculations than the Reynolds stress model because of its greater computational efficiency.

It is clear that the stratified-flow research which is being planned here will make an important contribution in an area where very little data currently exists. I was impressed with the quality of the instrumentation which has been developed. My expectation is that given the funding and resources which have been dedicated to the stratified-flow research work the results are likely to be a definitive study of the subject and may, in fact, shed light on the nature of the mixing phenomenon in other types of flows as well. I believe that the Navy should stay informed about the research at DHL. I plan to visit DHL again in about a year. I will report on the progress which has been made at that time.

TURBULENCE RESEARCH AT THE EINDHOVEN UNIVERSITY OF TECHNOLOGY

by Eugene F. Brown.

At the Technical University of Eindhoven (THE) I visited the Fluid Mechanics and Heat Transfer Laboratory in the Department of Applied Physics. The group is fairly small, consisting of two professors and eight scientific staff members. However, they are extremely well equipped and are conducting several interesting projects in the fluid mechanics of turbulence. My host during much of the visit was Mr. C. Nieuwvelt, a member of the scientific staff.

The first stop on my tour was with Dr. J. Bessem, who is doing some experiments in a large (0.7×1.05 m^2) subsonic (2 to 6 m/s) wind tunnel. Of particular interest were the coherent structures near the wall where a dense water fog was injected through flush-mounted slots in the wall. The intention was to correlate flow visualizations with measurements of the wall shear stress obtained with flush-mounted hot film probes. The visualization was carried out by simultaneous illumination in both the horizontal and vertical planes. Viewing the test section at an angle during illumination produces a three-dimensional visualization of the turbulence structure. This work is a follow-on to a previous study in which an investigation of the velocity/shear-stress correlation was carried out using a hot wire anemometer and a thermal-type wall shear stress meter.

The objective of the experiments is to understand the coherent turbulence structures in the near-wall region. If the structure of near-wall turbulence is better understood, ways of modifying the structure (for example, through the use of longitudinal grooves) can be improved. This in turn might lead to improved ways for reducing aerodynamic and hydrodynamic drag. The wall shear stress meter consisted of five 70-μ-wide by 700-μ-long titanium elements vacuum-deposited on a glass substrate. The separation between the elements was 700 μ.

From the shear stress readings, Bessem constructed shear stress maps such as the one in Figure 1, which shows the passage of regions of high and low shear stress as the flow passes over the meter. It was hoped that these maps would reveal large regions of low shear stress which could be correlated with the appearance of the low-speed meandering streaks which had been seen in the flow visualization studies. What was seen, instead, were large regions of

high shear stress. There might be two reasons for this. One is that the shear stress meter was too small to reveal the true dimensions of the low shear stress regions. Another reason might be the phase error of the wall shear stress measurements. A significant phase lag can be expected because of the large thermal mass of the glass substrate. In addition, the glass is responsible for a low signal-to-noise ratio because it absorbs much of the heat delivered to the film.

A. Koppius has been carrying out investigations of the near-wall turbulence structure in water in a $15\times30\text{-cm}^2$ water channel which was built specifically for this purpose. The water velocity in the channel is extremely small (only 10 to 30 cm/s). The Reynolds numbers are roughly equivalent to those achieved in THE's wind tunnel: 1×10^4 to 1.3×10^6 per meter. Based on the displacement thickness, the Reynolds number is approximately 2000.

Measurements were made with both three-wire, angled hot wire probes and a reference-beam anemometer system. In addition, the hydrogen-bubble technique was used to visualize the turbulent structures perpendicular to the plane of view. Multiple wires in the horizontal plane and a single wire in the horizontal and vertical plane were used. When the multiple and single wires were used together, photographs were made from an angle, thus producing three-dimensional images of the flow similar to those acquired with the laser sheet technique used in the wind tunnel studies. These images were enhanced by two-color illumination of the near-wall region. This was obtained with a colored filter in which the upper region was yellow and the lower region was blue. Color photographs then revealed motion in the direction normal to the floor of the channel. If, as shown in Figure 2, the blue portion of the light beam is the closest to the floor of the tunnel, a preponderance of yellow bubbles would disclose a region of high (positive) vertical velocity.

With this equipment and with a single, pulsed, horizontal wire, regions of relatively low stream-wise velocity and relatively strong positive vertical velocity were discovered. These so-called coherent structures were first observed by Kline in 1967 and named low-speed streaks. The vertical extent of the low-speed streaks was found to be a y^+ of approximately 120. (This is considerably greater than that observed by other investigators; however, this difference might simply be ascribed to a difference in the coherent structure

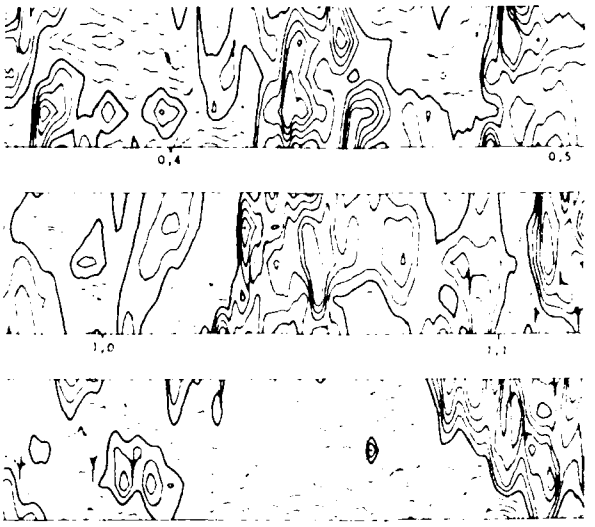


Figure 1. Typical shear stress map.

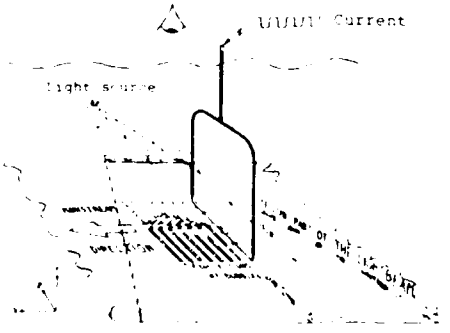


Figure 2. Two-color hydrogen bubble technique.

definition.) With the use of multiple wires located in the floor of the channel, these steaks were seen to meander slowly throughout the illuminated area, sometimes joining, sometimes separating, sometimes perturbed by other structures, but only a few of them ever having a visible beginning or end. One never sees an abrupt beginning or ending of a streak.

Perhaps the most controversial finding was the absence of Kline's bursting process. In an as yet unpublished report by R. Blokland and K.K. Prasad, who collaborated with A. Koppius in this work, the bursting phenomenon is attributed to nothing more than the continuous vertical and span-wise undulation of the low-speed streaks. It is claimed, therefore, that the proper interpretation of previous dye injection

and hydrogen-bubble experiments is not that bursting took place, as claimed, but that the apparent bursting is simply the detection of a continuous process in which the visualizing medium is first sucked into the low-speed streak, lifted up, and transported through the streak away from the wall.

Work is continuing to examine the relative effectiveness of grooved plates in organizing the meandering near-wall turbulence structure, thereby reducing drag. For this purpose Koppius has designed an inductive-type drag balance which has been mounted in the floor of his water channel. Since the expected reduction of drag due to the grooves is only about 4 percent, extremely careful measurement of the drag forces is necessary. Even with a fairly large (approximately 40×12 cm^2) plate, displacements on the order of only 100 microns are expected. In such situations elaborate precautions must be taken to control the effects of thermal expansion caused by spurious temperature fluctuations. In fact it seems that the temperature must be controlled to within ±0.05°C. Even with a refrigeration system installed to remove what would ordinarily be regarded as the inconsequential temperature increase due to the pumping of the water through the channel, repeatable measurements could not be made. A more accurate temperature control system including possibly better thermal insulation of the balance may be necessary before reliable measurements can be made.

Conclusion

I was impressed with the variety of experiments under way at THE in the area of turbulence-structure research and control. At the present time it seems that their research is well funded and that they lack neither for facilities, nor instrumentation, nor personnel. There are some signs that this might change, however. At the present time the Dutch technical universities have sustained deep cuts in their instrumentation budgets and the traditional 5-year engineering program has been reduced to 4. This, combined with attractive job offers which the 4-year candidates are receiving (this year's graduating class is the first to have gone through the new 4-year program), might mean that the Dutch universities will be hard pressed to continue their research programs at their current levels. Provided that THE is not too severely impacted by these changes, I anticipate that the Fluid Mechanics and Heat Transfer Laboratory will continue to make significant contributions to the field of turbulence research in the years to come.

4/1/86

TURBULENCE RESEARCH AT IMFL

by Eugene F. Brown.

My visit to the Institut de Méchanique des Fluides de Lille (IMFL) was hosted by Dr. Danny Vandromme, who is a Senior Scientist in the Aerodynamics Group. IMFL, founded before the Second World War, is located in the city of Lille, in Northern France, and for a number of years was attached to the University of Lille. In 1983 it became one of several laboratories operated by the Office National d'Études et de Recherches Aérospatiales (ONERA). IMFL employs 108 people, including 32 research engineers and 21 technicians. They are organized into four operational research groups including Flight Mechanics, Structural Mechanics, Applied Fluid Mechanics, and Aerodynamics. The Aerodynamics Group is concerned with unsteady and separated flows, aerodynamics of explosions and gunfire, turbulent flows, and flow characterization techniques. During my visit to the Aerodynamics Group I saw examples of research in all four areas. Much of the research at IMFL is contracted by the French Ministry of Defense.

IMFL's principal experimental facilities are its 2.5-m-diameter low-speed tunnel, a small (20×14 cm^2) continuous flow transonic tunnel, and a slightly larger (20×15 cm^2) continuous flow subsonic tunnel. Since 1977 IMFL has undertaken a vigorous instrumentation development program dedicated to improving the flow visualization used in these wind tunnels. Of particular interest was the development of techniques which would allow the visualization of unsteady phenomena.

An example of such a technique is their Cranz-Schardin chrono-lens system. The chrono-lens system consists of a set of 24 spark sources producing flashes of 300 nanosecond duration and a camera equipped with 24 lenses which records the results on a single 18×24-cm^2 photograph. The time interval between two successive sparks can be set continuously between 0.1 μs and 1 s. This system has been used to visualize the evolution of wakes shed by blunt bodies and

the muzzle-blast phenomenon. One implementation of this system allows schlieren photography or shadowgraphs to be taken from two different directions at the same time.

For incompressible flows, a four-cavity, double-flash, pulsed ruby laser has been developed using four ruby lasers and Pockels cells. A cylindrical lens is used to produce a light sheet which illuminates the test section, and the images are recorded on a high-speed motion picture camera. With this system eight pulses of 20 nanosecond duration separated by intervals from 5 to 500 μs can be realized. Using smoke injection, the researchers have used this technique to investigate the flow in a two-dimensional inlet at high angle of attack. In the series of photographs which was taken, the turbulence structure and, in particular, the vortex pairing phenomenon can be clearly seen.

Vandromme plans to use this laser to investigate the near-wall turbulence structure in a $0.3 \times 0.3\text{-m}^2$, 40-m/s wind tunnel he is building. He intends to use the laser systems to produce multiple, strobe-like photographs by triggering on the output of a wall-mounted hot film probe. The light sheets will be oriented at 45° with respect to the horizontal to more fully illuminate the turbulence structures. He intends to correlate these visualizations with shear stress measurements made with a hot film probe designed by J. Coustiex at the Centre d' Études et de Recherches de Toulouse. Vandromme also plans to make laser Doppler velocimeter measurements of the turbulence structures. (See page 237 for a similar study being undertaken at the Technical University of Eindhoven.) In this study the motivation is the eventual control of the near-wall turbulence in order to reduce drag.

In a new development, the pulsed laser system has been used to make instantaneous three-dimensional holographs. In this work, microparticles are injected into the flow as tracers. The holograph consists of a double image of each particle separated in time by the pulse interval of the double-flash laser. From the distance traversed by each of the particles, the velocity in the plane of view can be calculated, and from the distance between the planes of focus of the two images the velocity component in the direction perpendicular to the field of view can be calculated.

The holographic velocimetry technique has the advantage that it is able to capture an entire three-dimensional flow field at once whereas conventional laser Doppler velocimetry only measures the velocity at a single point. Holographic velocimetry also has the advantage that, compared with laser speckle velocimetry, the data reduction is simpler. On the other hand, the velocity fields are much more sparcely mapped than with speckle velocimetry. This is so because if too many particles are present in the field of view, it becomes impossible to pair the particle images and the interpretation of the holograph therefore becomes impossible.

Experiments have been completed on low-speed airflow over a 90-degree wedge, and good agreement with the theoretical calculation of this flow has been obtained. The technique places heavy demands on the data reduction process since a complete flow map requires several hundred particles to be tracked. It is natural, therefore, to seek some means of automation. During the past 2 years the equipment necessary to accomplish this has been assembled. It consists of a Tigre 3000 image processing system manufactured in France and based on the PDP 11/45 minicomputer. The system (which costs approximately $150,000) allows a three-dimensional hologram to be scanned, the necessary calculations completed automatically, and a flow map produced in a few hours. This would have required days using the former manual system shown in Figure 1. Using the test case of the flow over the 90-degree wedge, the holographic method has been found to give results which agree well with theoretical calculations; however, proper attention must be given to selecting microparticles of the proper density.

Vandromme's principal contributions are in the area of computational rather than experimental fluid dynamics. In this connection he is fortunate to have access to the Cray 1S operated by the Centre National de Recherche Scientifique. Vandromme is very well known to computational fluid dynamicists in the US, having spent a year at NASA Ames in 1980 as a National Research Council Fellow and has worked at NASA Ames each summer since that time under a contract administered by the University of California at Davis. He has been involved in the calculation of wakes, transonic flow, and flows in laser cavities and internal combustion engines. His current work, done in collaboration with R.W. MacCormack of Stanford University, involves the development of second-order-accurate, flux-splitting schemes for the solution of the Navier-Stokes equations.

4/3/86

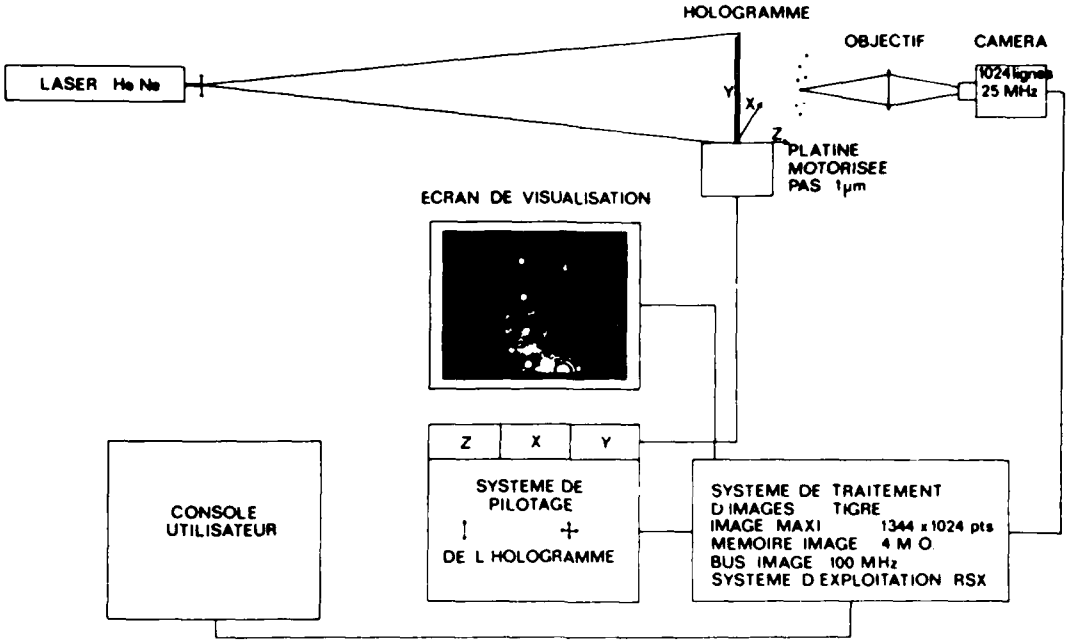


Figure 1. Data reduction from a holograph.

Ocean Sciences

OCEANOGRAPHY RESEARCH AT TWO UK UNIVERSITIES

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the U.S. Naval Academy, where he is Associate Chairman of the Oceanography Department.

I recently visited the University College of North Wales (UCNW), Bangor, and Exeter University, Exeter, to explore their oceanographic research activities. I found two widely differing situations. UCNW has an established oceanography department which is being reorganized for what seems to be administrative and probably technical strengthening. Exeter University, by contrast, has no oceanographic department, but has a few individuals who are doing what appears to be some fine oceanographic work.

Oceanography Research at The University College of North Wales

UCNW is one of two colleges in the UK (the University of Southampton is the other) that continues to receive grant money from the University Grants Council for the specific purpose of supporting an oceanography department. (Oceanography departments still exist at Liverpool and Swansea, although they are somewhat reduced in size, since these two schools have opted to fund their ocean sciences departments from other resources.)

School of Ocean Sciences. Starting in August 1986, the administrative structure at North Wales will be somewhat different; all the academic oceanographic activity will be contained within a new School of Ocean Sciences to be headed by Professor Taylor Smith. The new school will include a Biological Oceanography Department, headed by Professor Peter Williams, and a Physical Oceanography Department, with Professor J. Darbyshire directing operations until his retirement when Professor John Simpson is expected to take over.

Biological Oceanography Department. At this time the eight staff members of the Biological Oceanography Department seem to be concerned primarily with studies on larger animals. This work includes some mariculture activity directed toward prawns and the development of optimal foods to make them attractive as a commercial product. Dr. Williams

has indicated that he would like to encourage more research directed toward the bottom of the food chain.

Physical Oceanography Department. Professor John Simpson is involved in a number of different projects within the general area of physical oceanography. He has been looking at shelf-sea fronts--those oceanic fronts occurring near the continental shelf break--using satellite IR imagery and *in situ* measurements. Interestingly enough, all National Environmental Research Council grantees may obtain processed IR imagery free of charge from the processing facility at the University of Dundee. Of concern to Simpson is the general problem of sediment transport, with particular attention to the Irish Sea. Because the amount of sediment transported is directly related to settling rates of the suspended particulates along with bottom scouring rates, both of these processes are under study, with special emphasis on binding mechanisms of bottom sediments.

As is reasonably well known, the solar energy reflected from sediment-laden waters, such as those in the Irish Sea, tends to be different in character from that reflected by clearer ocean waters. The normal calibrating assumption made by deep-water investigators that the reflected energy in the near infrared is zero does not hold for coastal waters. Because of this, Simpson has been forced to develop new algorithms relating the E_{450} to E_{550} ratio to chlorophyll concentrations.

Work also continues, under Professor Simpson's direction, on the study of longitudinal estuarine fronts. These fronts, that apparently split an estuary up the middle along its major axis, have been found to exist in just about all southern UK estuaries on the flood tide. This is in contrast to North America, where the phenomenon has not yet been observed, probably due to the much smaller tidal forces present. Although no parameter has been developed as yet that will forecast the physical characteristics of an estuary necessary to produce this unusual frontal condition, it is obviously related to estuarine width since all southern UK estuaries are quite narrow.

Another project involving the physical oceanography staff is a study of the Scottish coastal current. Under the direction of A.E. Hill, data taken by a land-based-radar current-measuring system are being used to monitor the current. Although this methodology has been used before, the system now appears to be developed to the point of becoming commercially exploitable. It uses two shore-based radars oriented at about 90 degrees to each other, each of which measures the Doppler shift of the returning echo so that two rectilinear components of the motion may be obtained. Current motion is separated from surface wave motion by noting the phase-speed of ocean waves of wavelength corresponding to the Bragg frequency of the radar and subtracting this speed from the indicated speed as given by the system. Comparisons of data taken with radar and emplaced conventional current meters show very good correlations for east-west components of the current but a somewhat poorer relationship for the north-south components. Since the major tidal flow is in an east-west direction, it would be expected that the north-south flow would be highly variable.

Utilizing IR satellite imagery of the coastal waters off Portugal, Dr. E.D. Barton has noticed indications of a rather well-developed upwelling region similar in many respects to that off the coast of California. The cold upwelling water is apparently moving away from the coast in such a manner as to develop eddies, giving rise to a curved, filamentary structure seen on the IR photos. This year, during the period of 5 September to 4 October, Barton, in conjunction with two Portuguese scientists (Drs. Isabel and Armando Fiuza) will be taking *in situ* data coincident with satellite overflights in an attempt to relate the three-dimensional dynamics of the system to the surface IR signature. At the same time, the investigators hope to start a long-term statistical study that will show the temporal variability, both short and long term.

The work of Professor J. Darbyshire in shallow-water waves is known worldwide, and it continues even though the amount of his work is starting to taper off a little. Dr. A.M. Davis is now helping him to address the problems associated with waves in shoaling areas, especially the effects of shoaling bottoms on waves and sediment transport produced by wave action.

Unit for Coastal and Estuarine Studies. A separate part of the North Wales marine science organization is a group called the Unit for Coastal and Estuarine Studies (UCES), headed by Dr. Alan J. Elliott. Dr. Elliott is known to some stateside members of the oceanographic community since he spent a few years with Pritchard's group at The Johns Hopkins University during the 1970's. Since Dr. Elliot assumed the leadership position a few years ago, the staff has grown from two to a total of six, including three Ph.D.'s. The unit is presently operating on an annual

budget of about $250,000, all derived from outside contracts. Although UCES is basically a problem-solving group working on government and industrial projects, the nature of the work is such that the group is able to involve a few graduate students working on associated tasks.

Much of the work done by UCES involves numerical modeling, using the university's computer system, along with a number of unit-owned components. A good example of ongoing modeling work is their oil-spill model. This model has worked quite well, as it allows for the contaminant to be distributed through the surface layers by turbulence and also predicts an elongated-patch shape distortion effect. Since input to the model includes parameters such as pollutant density and viscosity, along with wind and current descriptors, it has proved to be very useful for prediction of dispersion of many types of spills. Other projects include a circulation model for the harbor at Kingston, Jamaica, sponsored by the Nuffield Foundation, and work for the British Admiralty on internal waves and vertical mixing in the Irish Sea. UCES is obviously developing a reputation for excellence, and that reputation is spreading, as is evident by the fact that Dr. Richard Hires from Stevens Institute of Technology will be spending his sabbatical with the Unit later this year.

Oceanography Research at Exeter University

Exeter University, by contrast, is a small school and has no oceanography department as such. However, there are a few isolated individuals working at this institution doing what appears to be very good work. It is apparently fairly common in the UK for studies in theoretical oceanography to be performed within the structure of mathematics departments.

Dr. Sasithorn Aranuvachapun Willmot, who has a research grant in the Department of Mathematical Statistics and Operational Research, is in the process of developing new algorithms to better describe the effect of the atmosphere on coastal zone color scanner (CZCS) satellite images. Since the CZCS filters are narrow bands, atmospheric aerosols strongly influence radiance values received by the sensor. By studying various aerosol size distributions and calculating the irradiance levels to be expected, she has managed to improve obtainable accuracies by a marked amount under certain conditions.

One of the by-products of my visit to Exeter was the opportunity to see Dr. Willmot's image processing system. She has managed to tie her IBM AT personal computer into the university's mainframe and work these two devices together as a reasonably inexpensive and effective image processor. By using the hard disc in the IBM AT she has made it possible to maintain an entire scene in memory, so that various experimental atmospheric attenuation algorithms may be tried at will. The advantage of this system is that every step of the image processing procedure may be modified and controlled by the operator. Although the system is still so new it is not completely debugged, it appears to have great promise for the serious researcher.

I also visited two researchers in the Mathematics Department who are engaged in more classical oceanographic projects. Dr. Andrew Willmot has one of the new long-term grants being given to promising young scientists in the UK to prevent them from going abroad. He is involved in the study of long-period waves (such as Rossby waves), both surface and internal, and their effect on density distribution; he is also studying various other dynamic characteristics of the oceanic volume. Dr. Steven S. Maskell is attempting to model effects of bathymetric features on oceanic dynamic properties. He is not limiting his study to shallow water, but is considering the deep oceanic environment as well.

Conclusion

The University College of North Wales appears to be in process of developing a first-class oceanography research activity. By contrast, Exeter University has no oceanographic department, but some noteworthy work is being done there by individual scientists.

3/20/86

Physics

THE 50TH ANNUAL MEETING OF THE GERMAN PHYSICAL SOCIETY

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

The ancient city of learning and scholarship, Heidelberg, West Germany,

hosted a lively and festive assembly from 17 through 21 March: the 50th Annual Meeting of The Physical Society of Germany. (The first annual meeting was held in 1922.) The site was chosen in part because Heidelberg University celebrates its 600th birthday this year.

Over 2200 people participated, so that little personal cross-disciplinary exchange was possible. Nevertheless, the mammoth meeting was made manageable by a careful programing procedure and by the spacious layout of the modern university campus where the sessions were held.

The 1130 talks were grouped as follows:

- Plenary overviews (only eight)
- Principal lectures (32, sorted by subject area)
- Two public evening lectures
- Three tutorials on trends in physics
- Over 100 special review-reports of the divisions
- 900 short papers read in the sessions of the divisions
- A tolerable number (only about 60) of poster-papers

The following groups and divisions of the society contributed:

- Nuclear physics
- Particle physics
- Atomic physics
- Molecular physics
- Quantum optics
- Energy and technology

Even though divisions of the Austrian and the Swiss Physical Societies participated in organizing some sessions, and even though there were a few invited foreign speakers, practically all papers were presented in German and almost all participants were West German.

Surprisingly, the plenary overview talks did not reveal any particular preoccupations: they were eclectically selected. One could hear about nuclear magnetic resonance, quarkmatter, modeling of electromagnetic fields, the single-atom maser, and phase transitions. The festive (rather lengthy) special meeting session highlighted, not surprisingly, K. v. Klitzing (Max Planck Institute for Solid State Research, Stuttgart), who gave an enthusiastic and amusing talk about his Nobel-prize-winning work on the quantum hall effect.

Perhaps more revealing, in regard to current efforts of concentration, were the tutorials on trends in physics: Frustrated systems, optical communication and integrated optics, as well as new areas in low-temperature physics were covered.

The participants were given a special treat in one of the public lectures when R. Lüst, head of the European Space Agency, reported on the dramatic encounter of the Giotto spacecraft with Halley's Comet, only a week after this historic event took place.

The meetings were accompanied by an interesting, medium-sized industrial exhibition. I found it a refreshing innovation that the conference program contained rather detailed descriptions of the truly new products shown in the exhibits. (I can provide a copy on request.)

I, personally, concentrated on covering the sessions of the quantum optics division, and wrote a formal conference report (ONRL-C-3-86), which is available by filling in the postcard on the back cover page of this issue. Therefore, I shall give only a very brief overview and orientation.

The selected topics for the principal lectures and plenary overviews in this area were: (1) ultrashort UV and VUV laser pulses (F.P. Schäfer, Max Planck Institute for Biophysical-Chemistry, Göttingen); (2) high-power lasers in the EUREKA Program (L. Cleemann, VDI Technology Center, Düsseldorf); (3) construction of a single-atom maser and observational quantum electrodynamics within a resonator (H. Walther, Max Planck Institute for Quantum Optics, Garching); and, somewhat inexplicably, (4) nuclear magnetic resonance applications in biology and medical science (K.H. Hauser, Max Planck Institute for Medical Research, Heidelberg).

The reports and short papers were grouped as follows:

- Ultrafast and coherent spectroscopy (two sessions)
- Integrated optics and optical fibers
- Semiconductor lasers
- Frequency multiplication and phonon interactions
- Phase congugation and photorefractive effects
- General laser spectroscopy
- Photochemistry and photobiology
- Dye lasers and frequency stabilization
- Optical bistability and optical computers
- Solid state lasers (two sessions)
- Optical chaos and photon-statistics
- Industrial reports and miscellaneous topics

In these sessions, of which two always ran parallel, over 100 presentations were given. Admittedly, the levels varied greatly (in my opinion, more than

at quantum optics/optoelectronics meetings which are organized independently from a bigger society meeting), but it was quite clear to me that West German physicists are working successfully on the frontiers of quantum optics. (Perhaps I should mention in this context that almost all speakers were physicists working at academic institutions, in contrast to specific optoelectronics or laser conferences where many contributors are engineers and come from a more varied background.)

Once again, I was struck by the conscious effort of the German researchers to do thorough, in-depth work rather than focus on the sensational. This, I think, is fairly typical at European physics meetings.

3/31/-e

News and Notes

THE NATO SCIENCE PROGRAM

NATO has, in addition to its better known political and military dimensions, a "third dimension," which seeks to encourage interaction between peoples, to consider some of the challenges facing our modern society, and to foster the development of the scientific potential of Alliance countries. (See *ESN* 39-1: 25-26 [1985].)

The NATO Science Program, established in 1958, plays a major role in this third dimension. Its basic objective is the enhancement of the scientific and technological capabilities of the Alliance through a variety of activities aimed at promoting international scientific cooperation in a wide range of disciplines. Most fields of science are eligible for support under general exchange programs of research fellowships, collaborative research grants, advanced study institutes, and advanced research workshops. However, the NATO Science Program also sponsors, under so-called "special programs," a few specific areas of science which deserve concentrated effort and preferential support. These are:

- Global transport mechanisms in the geosciences
- Selective activation of molecules
- Sensory systems for robotic control
- Cell to cell signals in plants and animals
- Physics of systems of low dimensionality

Following are descriptions of the sponsored activities.

Advanced research workshops. Opportunities are offered to leading scientists to organize high-level 3- to 5-day workshops with 30 to 50 participants in order to review the state of the art in a given scientific field and to formulate recommendations for future research. Funds are provided to workshop directors for partial coverage of expenses related to the organization of the meetings and expenses for participants.

Advanced study institutes. Opportunities are offered to leading scientists to organize 2-week advanced meetings of a tutorial character, involving 8 to 15 lecturers and 50 to 80 participants, normally of postdoctoral level. The objectives of an advanced study institute are to promote the release and exchange of information not available in standard university courses, to impart knowledge and experience to young scientists, and to favor professional contacts among scientists. Funds are provided to the advanced study institute directors for partial coverage of expenses related to the organization of the meetings and expenses for lecturers and participants.

Conferences. In exceptional cases, opportunities are offered for the organization of NATO conferences similar to those promoted by professional societies. These conferences should possess the following features: sharp topical focus, wide international participation, and wide dissemination of results in open literature. Funds are provided to conference organizers for partial coverage of expenses related to the organization of the conferences.

Collaborative research. Opportunities are offered to scientists of universities or industrial research laboratories from two or more NATO countries to develop joint research projects. The grants available for this purpose are intended to cover the additional costs related to the international collaboration (mainly travel and living expenses for visits by members of both project teams to the collaborating institutions abroad) rather than the major research costs (e.g., salaries, equipment, consumables) which are expected to be covered nationally. Grants are awarded initially for 1 year with a review at the end of this period for possible renewal.

Research, study and lecture visits. Opportunities are offered to a NATO country to perform research and/or to seek information, advice, and advanced instruction in another member country. The duration of the visits should not normally exceed 2 to 3 months. Opportunities are also offered to enable leading scientists to make short visits to several universities, research institutions, or scientific societies in other member countries to lecture and hold discussions and seminars on the results of their recent work. Funds are provided for partial coverage of travel and living expenses abroad.

Applications should be submitted well in advance of the date foreseen for the initiation of a proposed activity in order to allow sufficient time for its preparation and evaluation by the panel, which normally meets only two times a year (usually in spring and fall).

Specific application forms for advanced research workshops, advanced study institutes, and collaborative research grants are available from:

Scientific Affairs Division
NATO
B-1110 Brussels, Belgium

Specific forms are not required for the other activities; application should be made by letter to the address above.

Jerome Williams
4/18/86

FLUID MECHANICS AT THE FREE UNIVERSITY OF BRUSSELS

Dr. Charles Hirsch holds the Chair of Fluid Mechanics at the Free University of Brussels (VUB). This is the Flemish (Dutch) speaking half of what was formerly an entirely French-speaking university. There is no fluid mechanics research conducted in the French-speaking university.

As is typical in Belgian universities, the professor does all of the teaching. In Hirsch's case this means courses in general fluid mechanics for students in their third year, courses in turbomachinery for students in their fourth year, and various specialized courses in hydraulics, biofluid dynamics, and ground water flows. Assisting him in these courses is a research staff of 20, including research assistants, research associates, and doctoral candidates. The primary responsibility of the research staff, however, is to assist Hirsch in his research activities, which are currently composed of turbulence research, turbomachinery calculations, computational fluid dynamics, industrial aerodynamics, and wind turbine design. His research sponsors have included the Belgian National Science Foundation, Lockheed Corporation, the United States Army Research and Standardization Group-United Kingdom, and the United Technologies Research Center.

The work which was supported by the US Army and the Belgian National Science Foundation consisted of measuring the velocity profiles and turbulence properties of subsonic flow over a pitching NACA 0012 airfoil. These measurements used a rotating, slanted hot wire mounted on the airfoil (see Figure 1). The airfoil had a chord of 60 cm and was mounted in the VUB's 2-m×1-m wind tunnel. The free stream velocity was 17 m/s and the free turbulence level was less than 0.02 percent. A trip wire was used at 10 percent chord. Leading edge pressure taps were used to trigger the sampling of the measured hot wire signals. Hot wire traverses at eight chordwise positions were made. Tests were run for conditions simulating unstalled, stall onset, and fully stalled conditions. In regions of massive separation,

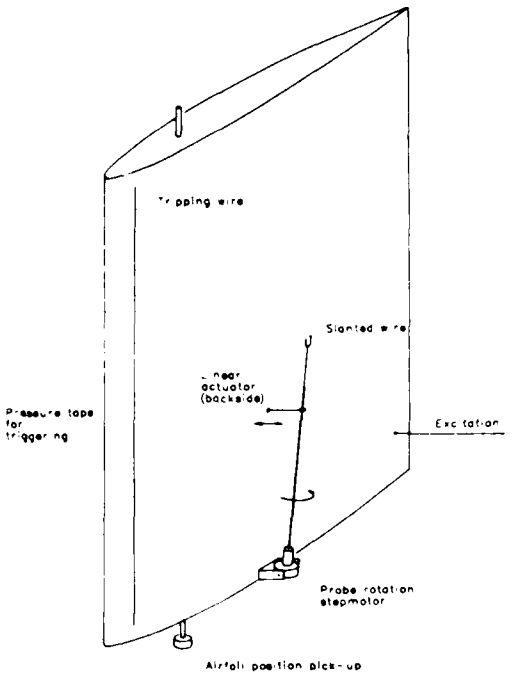


Figure 1. Experimental set-up.

representing stalled operation, turbulence velocities far exceeding the mean velocities were produced. In such cases extracting the mean velocity from the hot wire signal is a difficult task. Hirsch analyzed this situation using a Gaussian probability density function for the velocity. He was able to derive an expression for the difference between the true mean velocity and the measured mean velocity in terms of a degenerate hypergeometric function.

Detailed measurements of the flow over the airfoil were made. Of particular interest were the structure and location of shed vortices and regions of separated flow. Turbulence information included the rms value of chord-wise turbulence velocity; the Reynolds stress; the time rate of change of the turbulence kinetic energy; and the convection, production, dissipation, and diffusion of kinetic energy.

In the unstalled case, the results were similar to the flat plate boundary layer measurements of Klebanoff. For stall onset, a vortex was detected at the leading edge which appeared as a bubble and disappeared without separating fully. Full stall can be produced by increasing the reduced frequency or by increasing the maximum incidence. In these cases, negative Reynolds stresses and negative turbulence kinetic energy production were observed in front of, and in the center of, the leading edge vortex.

A continuation of this work, funded by Lockheed, will soon be under way. In these experiments, data at logarithmically rather than linearly distributed points will be collected in the boundary layer, and the flow will be allowed to transition naturally rather than being tripped.

In the turbomachinery area, experiments are being conducted to examine the three-dimensional nature of secondary flows near blade tips. For these measurements a cascade tunnel has been constructed in which a moving belt serves as one of the end walls. In this facility, detailed tip clearance measurements can be made with and without the belt in motion. The purpose of the moving belt is to simulate the relative motion between the rotating blade and a stationary shroud.

In addition to the tunnel with the cascade end wall, Hirsch's experimental facilities consist of two subsonic wind tunnels that share a common rail-mounted blower which has a maximum capacity of 60,000 cfm. Both wind tunnels have rather long, 8-m, test sections. The first tunnel has a cross section of nominally 1×2 m^2 and is used for industrial aerodynamic tests such as the flow over bridges and microclimate simulations for environmental and urban architectural studies. The atmospheric boundary layer can be simulated by blocks placed on the floor of the tunnel. The second tunnel is similar in size and is presently fitted with a test section of 1.35×0.45 m^2 cross section and an adjustable upper wall for use in modifying the pressure gradient in the test section. This was used in some recent studies for Lockheed on the effect of pressure gradient on turbulence structure.

In addition to this, Hirsch has sites both in Brussels and in Zeebrugge for his wind energy studies. At the present time he is in the process of constructing a highly instrumented, 5-m blade, horizontal-axis wind turbine. This is a one-tenth scale model of a commercial system. At the present time approximately eight of his research staff are working in the wind energy area, and this activity represents a significant portion of his research budget.

For his computational fluid dynamics (CFD) research, Hirsch uses a CDC Cyber 170/750 mainframe computer. He regards this computational facility as being barely adequate for his computational needs, and therefore, in connection with some work which he is proposing for the European HERMES project, he is pursuing a telephone link with a Cray.

Hirsch has discovered what he believes to be a significant improvement in implicit CFD methods. It involves a technique for diagonallizing the time-dependent Euler and Navier-Stokes equations. This new formulation of the governing equations allows a diagonally dominant coefficient matrix to be produced without the need for splitting. This is accomplished by use of characteristic variables in which two directions are combined: one consisting of the direction given by the pressure gradient and the other consisting of the direction given by the stress tensor. Hirsch characterized the scheme as being box-implicit in character. Although at present only one-dimensional tests have been completed, the technique has been shown to be unconditionally stable and to allow a converged solution to be obtained with a cell Reynolds number as high as 10^{12}. Convergence was achieved in ten time steps. The expectation is that with this new diagonalization, Hirsch's method will attain a speed which is comparable with the very best of the current explicit methods. This

work was first presented at the Conference on Hyperbolic Nonlinear Problems in January 1986 in St-Étienne, France. This is an important new development and should be closely followed.

Eugene F. Brown
3/31/86

A NEW JOURNAL ON OPTICAL SENSORS

Since the advent of the laser, remarkable developments have also taken place in the fields of electronics and optics and, in more recent years, these fields have come together in the new science and technology of optoelectronics. Optical signal processing and optical sensors have achieved high prominence and are vital to many naval functions.

The International Journal of Optical Sensors is a new handsomely produced, bimonthly publication dedicated to all aspects of the technology of optical sensors, including theoretical principles, signal processing, materials science, device fabrication, packaging, systems design, applications, and economics considerations. It provides rapid publication of both review articles and refereed original papers. No page charges will be levied.

All correspondence on editorial matters should be sent to Dr. S. Chomet, Department of Physics, King's College, Strand, London WC2R 2LS. Subscriptions (£95 [about $146] for 6 issues) are handled by Newman-Hemisphere, 10 Bywater Street, London, SW3 4XD.

The journal was founded in January 1986 by three King's College professors (A.J. Rogers, R.J. Weiss, and S. Chomet) and the truly international editorial board has 26 members.

And if you, dear reader, ask why yet another new journal was launched, the first issue gives a charming explanation: "There is an old saying that when two Greeks get together, they open a restaurant. ... When two scientists get together, they write a book or start a new journal. [These] two editors ... met in a Greek restaurant and convinced each other that photons will replace electrons for most applications where information is extracted, processed, or conveyed. That conviction is the raison d'être for [this] Journal."

Paul Roman
3/4/86

A NEW SOCIETY FOR RADIATION PHYSICS

The International Radiation Physics Society (IRPS) was founded last September in Ferrara, Italy, during the meetings of the Third International Symposium on Radiation Physics (ISRP).

The constitution defines radiation physics (RP) rather broadly by stating the RP is "the branch of science which deals with the physical aspects of interactions of ionizing radiations (both electromagnetic and particulate) with matter."

The IRPS considers as its goals the global promotion of theoretical and experimental research in RP, investigation of physical aspects of interactions of radiations with living systems, education in RP, and the utilization of radiations for peaceful purposes. One of the planned activities of IRPS is the continued sponsorship of the series of ISRP; the other is the issuing of a newsletter.

The first president is Dr. P.K. Iyengar, Bhabha Atomic Research Center, Bombay, India. The society's secretary is Professor R.H. Pratt, Department of Physics and Astronomy, University of Pittsburgh, Pennsylvania (phone: 412-624-4304). He should be contacted regarding membership. Further information regarding IRPS may also be obtained from Dr. J. Hubbell, National Bureau of Standards, Washington, DC 20234, who is one of the most enthusiastic promoters of the society.

Paul Roman
3/4/86

NINETEENTH MEETING OF THE MATHEMATICAL STUDY GROUP WITH INDUSTRY

The Applied Mathematics Groupe at Oxford, under the direction of John and Hilary Ockendon, annually bring together at the Mathematical Institute representatives from industry with specific problems and members of the academic community with experience in modeling, analysis, and computation. An all-time record number of participants marked the latest meeting. This year the available expertise was increased by the creation of an organizing committee with representatives from Cambridge (Dr. John Hinch), Nottingham (Drs. Tony Green and T. Rogers), and Heriot-Watt (Dr. Andrew Lacey). The week generally went smoothly, with groups of academics (and a few Oxford graduate students) meeting

informally throughout the day to attempt to understand the problems and to develop methods of solution.

The problems presented by industry ranged from the manageable to the vague and ill-defined. Principal topics included:

- Some gas dynamics problems related to rock blasting (ICI)
- A model for the high-pressure discharge lamp (Thorn EMI)
- Wave propagation in two-phase fluids (CEGB, Leatherhead)
- Gas flow through tuyeres in a blast furnace (British Steel Corp., Teeside)
- Temperature stratification in a steel ladle (British Steel Corp.)
- Simulation of rheological behavior of concentrated multiphase dispersive systems (Unilever Research, Bedford)
- Air gap spinning (Courtauld's Research)
- A model for passive diffusion of active chemicals through the epidermis (Beecham)
- A model for ship slamming (Admiralty, Bath)

Clearly, some of these problems evolved from current interest in product development; however, some have been around for a long time and were of such a size as not to be suitable for a meeting of this kind.

There seems to have been great interest in this meeting from the applied mathematics community at large, judging from the fact that representatives also came from the US, Australia, the Netherlands, Italy, and West Germany. Clearly, this format is viewed with great optimism as a vehicle for involving mathematics with industry and industry with education. Some of the problems discussed at past meetings resulted in Ph.D. theses, with obvious benefit to the institutions and the individuals. Furthermore, some of the solutions proposed at past meetings resulted in new processes and a better understanding of old processes--with obvious benefit to industry. It may be that the success of these meetings is just a UK phenomenon, but it may be a concept that deserves wider consideration throughout the world.

No proceedings will be published, but separate informal reports will be available. Send inquiries to Dr. John Ockendon, Mathematical Institute, 24-29 St. Giles, Oxford OX1 3LB, UK.

Harry E. Williams
Harvey Mudd College
4/22/86

OCEANOLOGY 86 HIGHLIGHTS

The Oceanology 86 Conference was held from 4 through 7 March 1986, concurrent with the 11th World Dredging Congress, in Brighton, UK. Each of these meetings consisted of separate technical sessions and commercial displays. The commercial displays included 245 exhibits in the oceanology group and 60 exhibits associated with dredging. Although both displays were broad in their coverage, there appeared to be no startling breakthroughs displayed. The papers were somewhat of a disappointment since most were given by representatives of firms displaying wares for sale and amounted to a description of their products.

One of the exceptions was a report by Dr. G.J. Komen of the Royal Netherlands Meteorological Institute on the activities of the international wave-modeling group called WAM. This group consists of scientists representing 15 different institutions from a number of different countries including Norway, the UK, the Netherlands, France, Germany, Spain, Canada, and the US. Initially the WAM delegates spent some time comparing existing wave models to determine similarities and differences. They then organized the comparisons into two studies--SWAMP (deep-water wave models) and SWIM (shallow-water wave models), the major difference being the inclusion of bottom interference in SWIM. Differences between models showed up in the areas of growth rate and directional effects, whereas similarities were seen in that all models made assumptions about the spectral shape of the waves present, and they all tended to simplify the basic physics of wave generation.

After reviewing the SWIM and SWAMP studies, the delegates decided to produce a new model that did not make any assumptions with respect to spectral shape or of wave generation physics. Such a model has been developed and is being evaluated at the present time. Not only is it designed to produce growth curve analyses, directional aspects of wave systems, and the effects of a shoaling bottom, it is also constructed to utilize large amounts of data, such as might be available from data sources such as satellites. A global run has been accomplished, using a series of hindcast; this resulted in values from the model which differed from observed significant wave heights by ±50 cm, corresponding to an average error of about ±20 percent.

Another exception to the general tone of the conference was a discussion of a system and methodology to measure

the wave spectrum of an existing sea using land-based radar. Called Microwave Remote Sensing from the Ocean Surface (MIROS), this system uses Doppler shift data in conjunction with Bragg scattering information (see *MAS Bulletin* 77-84). Thus not only can the frequency of occurrence of different wave lengths be determined, but by separating out current motion from wave orbital motion, wave heights and periods can be determined. This system is useful for forecasting since it is possible to pick out the long-wave components early and to supply initialization values for numerical models.

As might be expected in a meeting of this nature, the topic of bathymetric measurements was not neglected. Multibeam systems, digital data storage systems, and systems in which navigational data and depth were recorded simultaneously were discussed. Three-dimensional pictorial outputs were almost commonplace, but specifications as to bottom feature resolution were hard to come by. One system, that has been a few years in development (and has still not reached the commercial prototype level), is somewhat unique in that it uses interferometric techniques so that multibeams are not required.

An interesting approach to the problem of maintenance dredging was a study to determine the seasonal variation of the density of bottom materials. As expected, during months of high turbulence the bottom layer of unconsolidated mud grew, while during the quiescent summer months this layer shrank as the sediment settled. Optimal dredging strategy was then developed on the basis of this pattern of bottom-layer thickness variation. A new bottom-density probe was also described. This device consists of a two-prong fork that is allowed to penetrate into the bottom. In one prong is a 10 millicurie radioactive source containing Ce-137, while the other prong contains a receiver. Since the energy loss across the prongs is related to mud density, it is possible to calibrate the receiver in mass density units.

As may be seen, most of the papers presented were application oriented and, as such, were of concern primarily to commercial interests. The exhibitors, on the other hand, did include representatives from some of the better oceanographic instrumentation manufacturers.

Jerome Williams
4/15/86

DO YOU HAVE AN ELECTRONIC MAIL ADDRESS?

Would you help us try out a new way to communicate short newsbriefs? If you send us your name, electronic mail address, and your areas of scientific interest, we will, depending on the response, try to develop an ONRLNET of readers. Send your information to: C.J. Fox, ESN Editor, by letter (address on back or by ARPANET (ONR@UK.AC.UCL.Cs).

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Naval Applications and Environmental Chemistry of Organotins, Padua, Italy, 11 September 1986.

Sixth International Symposium on Gas Flow and Chemical Lasers, Jerusalem, Israel, 8-12 September 1986.

Fractals and Chaos, Centro A. Volta, Como, Italy, 18-19 September 1986.

Aerodynamics at Low Reynolds Numbers, London, England, 15-17 October.

* * *

SCIENCE NEWSBRIEFS FOR APRIL AND MAY

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during April and May. *Science Newsbrief* provides concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number	Title
4-7	Fluid Mechanics Meetings in Europe 1986-1987, by Eugene F. Brown.
4-8	Seminars on Fluid Mechanics at the University of Cambridge, England, by Eugene F. Brown.
4-9	Seminars on Geophysical Fluid Dynamics at the University of Cambridge, UK, by LCDR Rich Kelley, USN.

APRIL MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during April. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
26-86	First Quarterly Index
27-86	German Torpedo Weapon Simulation
28-86	Acoustic Devices From a UK Company
29-86	Thermal Imaging Systems Technology in the UK
30-86	Aircraft Recovery System for Lightweight Torpedoes
31-86	1986 European Naval Forecast
32-86	New Design Concept for an Aircraft HUD from Smiths Industries in the UK
33-86	ASTOVL Technology Developments in the UK

ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

C-3-86 *Current German Laser and Quantum Optics Research Reviewed at the 50th Annual Meeting of the Physikalische Gesellschaft*, by Paul Roman. Advanced research at West German universities and research institutes in the general area of quantum optics was well represented at a large meeting in Heidelberg, March 1986. This report focuses on describing results in the areas of gas lasers, integrated optics, nonlinear processes, and novel solid-state lasers--with emphasis on the last.

C-4-86 *Workshop Conference on Growth Factors in the Nervous System*, by Claire E. Zomzely-Neurath. The scientific program of this workshop covered four topics: glial growth factors, neurotrophic factors, nonprotein factors, and factors affecting nerve growth in muscle. This report summarizes the presentations given under those topics.

R-1-86 *Welding Research in Scandinavia: An Assessment*, by Kenneth D. Challenger. The Scandinavian countries--Denmark, Finland, Norway, and Sweden--are making significant contributions to the science and technology of welding. Specific research topics which should be closely followed by US researchers are hyperbaric welding, CAD/CAM applications to welding, mathematical modeling of the weld process, and hydrogen assisted cracking of steel welds.

CHANGE REQUEST
NAVEUR-ONR-5605-1 (Rev. 3-85)

FOR YOUR CONVENIENCE . . .

Government regulations require up-to-date distribution lists for all periodicals. This form is provided for your convenience to indicate changes or corrections. If a change in our mailing lists should be made, or if you want any of the ONRE publications abstracted in this issue and listed below, please check the appropriate boxes. Fold on dotted lines, being sure our address is on the outside, tape or staple the lower edge together, and mail.

1. ☐ CHANGE OR CORRECT MY ADDRESS EFFECTIVE IMMEDIATELY OR (date)
2. ☐ DELETE MY NAME FROM DISTRIBUTION LIST
3. ☐ PLEASE SEND ME THE FOLLOWING ONRE PUBLICATIONS

Corrected or New Address

☐ C-3-86 ☐
☐ C-4-86 ☐
☐ R-1-86 ☐
☐ 4-7 ☐
☐ 4-8 ☐
☐ 4-9 ☐

Fold Here

Fold Here

FROM:

_____

_____

_____

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 12503 WASHINGTON DC

POSTAGE WILL BE PAID BY DEPARTMENT OF THE NAVY

Commanding Officer
Office of Naval Research, Branch Office
Box 39
FPO New York 09510-0700

END

DTIC

7-86